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A 10,000-Volt High-Speed Electric Locomotive.

MOST of the readers of FEILDEN'S MAGAZINE will be familiar with the investigations in connection with high-speed electric locomotives that were conducted in the autumn of 1901 by Messrs. Siemens and Halske, when continuous speeds of more than 155 kilometres per hour (at one time even 160·2 kilometres per hour) were reached by the railway motor-car constructed by this firm.

In a prolonged trial, with an average speed of about 120 kilometres (74 miles) per hour, a track of 230 kilometres (143 miles) was run over in two and three quarter hours, including fifteen stoppages, during which the temperature of the motors was only increased by 50 degs. Cent. (90 degs. Fahr.), and that of the transformers by only 30 degs. Cent. (54 degs. Fahr.). These figures also show that the proportions between the weight of the motor and the weight of the transformer were well calculated, since the latter, exposed to high-tension currents, became less heated than the former. At another trial the car withstood at 100 cycles a pressure of 15,000 volts unloaded, and 13,000 volts loaded, without any effort whatever, and showed no defects of insulation.

Unfortunately, however, the defects of the track construction necessitated repairs just at the time of high-speed tests. Speeds of 150 kilometres (93 miles) per hour showed that the rails were in general too weak, and the substructure not solid enough, although the road stood the strain in some places where the bed was more solidly constructed. It was not expected that a track weighing only 33 kilogrammes per metre (66 lbs. per yard) would stand the strain, so that it prevented the running trials being continued up to the maximum speed of 200 kilometres (124 miles) per hour, owing to the fact that the oscillation and other movements of the motor-car would have been too pronounced. It was proved, however, beyond all doubt that electric equipment for high-speed railways is satisfactory; and it was the opinion of all who took part in the trials that the only thing still needed to maintain good results was a strengthening of the mechanical portion.

On account of these troubles, the State Railways Administration put at the disposal of the committee conducting these tests heavier rails and the material necessary for laying them, and these new tests are going to be made on a road having a more substantial construction.

In spite of the fact that the electrical equipment of the motor-car justified the work which has been done, Messrs. Siemens & Halske have nevertheless

attempted to improve other conditions, which has resulted in a reduction of the total weight of the car. This reduction has effected a saving of power, of wear and tear on the rails and cost of maintenance. Also when running at full speed, and particularly when starting up from stopping points, a considerable saving of power to be transmitted has been shown.

By the courtesy of Messrs. Siemens & Halske, who have placed the necessary data in our hands, we are now enabled to give a full description of an electric locomotive, the design of which has been worked out by Herr Reichel, the chief engineer to the firm, which is the outcome of these later experiments.

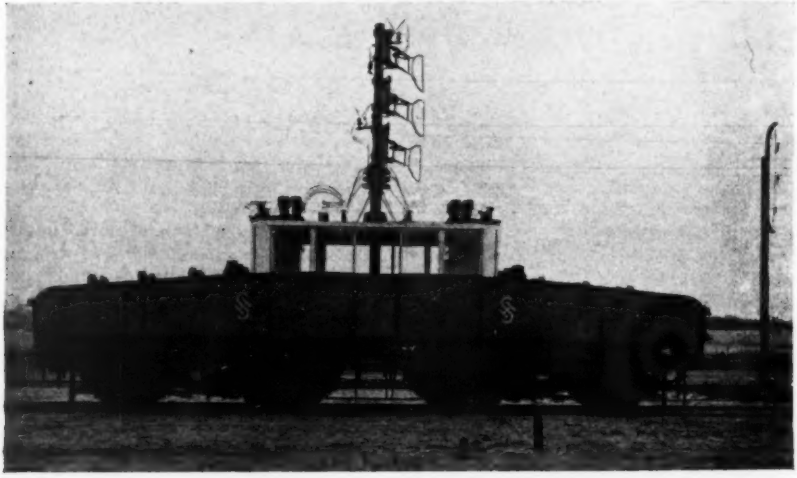


FIG. 1.—GENERAL VIEW OF LOCOMOTIVE.

As early as July 1900, during the elaboration of the first project, Herr Reichel conceived the idea of constructing motors for high-speed traction which would work, without the interposition of transformers, with a three-phase current at a tension of 10,000 volts, and which were to be tested by actual running trials with a locomotive. The proposals were accepted, and the new vehicle—an eight-wheel locomotive having four axles and two motors—was constructed. Owing to the absence of transformers, etc., the weight of a corresponding motor-car might be considerably reduced, viz.: from 96 tons to 76 tons, including the passengers. The motors of the locomotive were designed for producing a maximum power of 400 h.p. with 885 revolutions. For the experimental work the motors were not fixed directly on the axle, but through a gear train, having a ratio of one to two, by which arrangement a speed of 100 kilometres per hour would be possible. A transmission of one to four could have been adopted, corresponding to a speed of 50 kilometres (31 miles) per hour; or the motor could have been attached to the axles, through cranks, for 200 kilometres (124 miles) per hour. It was natural that the vehicle constructed should be a locomotive, as a motor-car would have necessitated a greater cost without presenting any appreciable advantages for these investigations over the one already existing.

As already stated, the locomotive has four axles and eight wheels and is made

entirely of iron. The body rests by means of two centre bolts on two trucks, each of which has two axles (Fig. 2). These are similar to those of the motor-car and

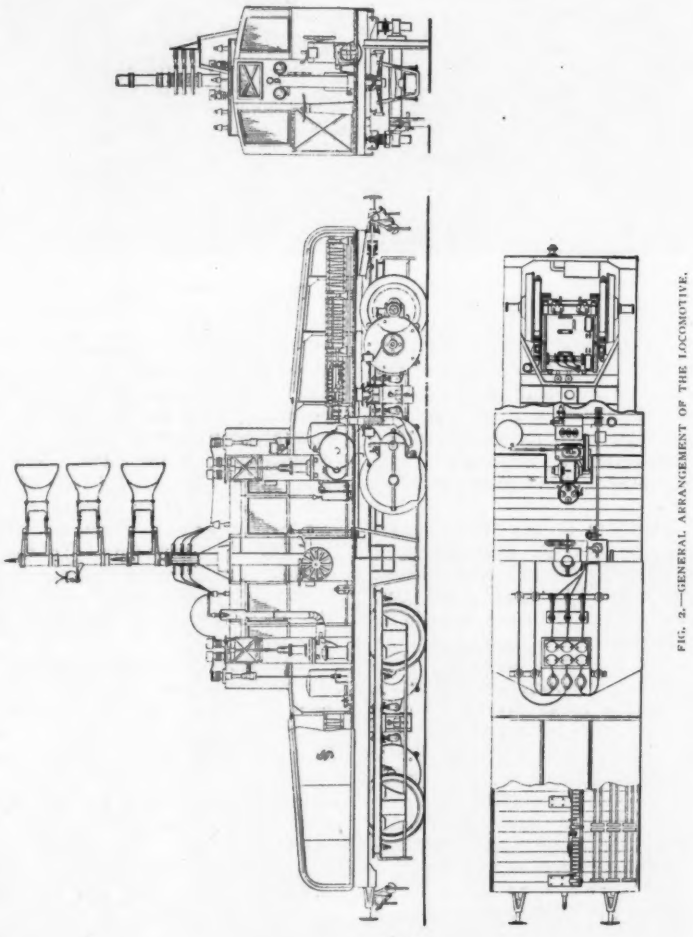


FIG. 2.—GENERAL ARRANGEMENT OF THE LOCOMOTIVE.

are constructed for a standard gauge. The wheels have a diameter of 1,250 millimetres and the wheel-base is three and one-quarter metres. The axle-boxes are similar to those of the high-speed motor-car.

The trucks were constructed for two motors on each (Fig. 3), although only one has been fitted. The iron underframe is reinforced by cross-beams and stays. The side-beams are formed of two channels, separated sufficiently from each other to admit the plate-springs being placed between the boxes and the frame. The frame is thus suspended but once, while the step for the centre-bolt, on

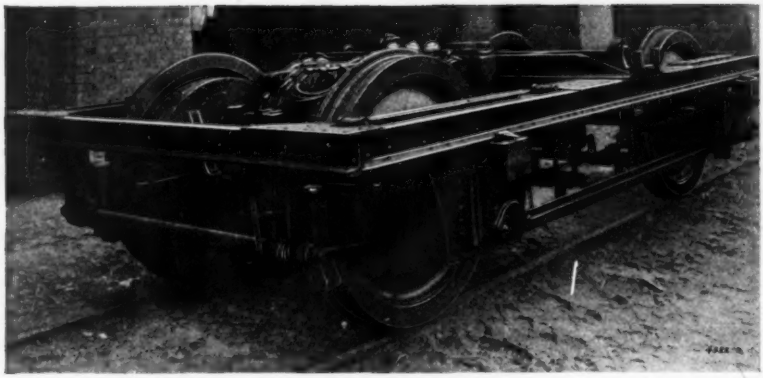


FIG. 3.—GENERAL VIEW OF ONE OF THE BOGEYS.

which the body rests, is suspended from the frame by means of plate-springs placed between the two cross-bars at the centre. At the two extremities of these cross-bars spring rollers are fitted for taking up the lateral oscillations of the body. The distance between the centre-bolts is 6·25 metres.

The brakes are of the Westinghouse type, and are operated by compressed air at a pressure of four atmospheres. They were designed to brake 90 per cent. of the total weight. There are eight shoes, and the arrangement is such that each truck can be treated as an independent vehicle. For this purpose each truck is furnished with a brake cylinder, with a diameter of 12 ins. and an auxiliary reservoir. The piston of the brake cylinder moves vertically, and operates the brake-rod by means of the cross-levers, of which there is one for each axle. The hand-brake is attached to the same brake-rod, but it works only on half of the shoes.

The body is 12·5 metres (41 ft.) long by 2·8 metres (9 ft.) wide, and consists of three compartments. The two low exterior compartments, having a length of 4·25 metres (14 ft.) and a height of from one to two metres, are rounded off at the ends and provided with two removable covers. The central compartment, having a length of four metres (13 ft.), a height of 2·3 metres (nearly 8 ft.), and a breadth of 2·8 metres (9 ft.), is placed symmetrically about the centre, and forms the engineer's cab. This contains all the apparatus for operation, while the rheostats for starting and the controllers are placed in the lower compartment of the body. The under-frame for the body is built up of channel beams, 300 by 75 by 10 mms. (11 ins. by 2·9 ins. by 0·3 in.), which are reinforced by stays and cross-bars. To the buffer beams at the extremities are fixed the draw and buffer gear, conforming to the specifications of the State Railway standard.

The floor of the under-frame is of wood, covered with thin plate-iron. The walls consist of strong plate-iron, reinforced by stays, and rest on the exterior of the side beams. They are so arranged that the interior is accessible from all sides. The exterior compartments are provided with hinged sheet-iron covers, which can be raised (Fig. 4). The middle compartment, forming the engineer's cabin, is closed on both sides and the ends by windows, permitting an outlook in all directions (Fig. 5). Access is had through a door on each side. In the middle of the driver's cab is the wiring duct, 0·9 by 1·1 metres (2 ft. 11 ins. by 3 ft. 7 ins.), containing the principal switches and fuses and the cables conducting current to the motors. The slightly projecting chambers which contain the resistance coils are

accessible from the driver's stand when the doors that close them are opened. The locomotive roof is also made of strong plate-iron and angle-irons, and supports the socket for the current collector, etc. The weight of the locomotive, including the electrical equipment, is about 40 tons, the electrical equipment weighing about 16 tons.

The most important point in the design of the motors is the winding Herr Reichel points out that this cannot be determined at the outset, as the details depend very greatly upon the arrangement of the mechanical parts. For instance, the number of windings is dependent upon the available width of the active iron, which again depends upon the length of that portion of the winding which projects beyond the grooves. This interrelation between one part and another rendered necessary a series of preliminary investigations before the final design could be arrived at.

The principal question was that of inserting the coils, with the aim of using as economically as possible the space between the wheels (Fig. 6). A special form of bearing, made in one piece, with sleeves, was fitted. This enters deeply into the interior of the motor, within the space enclosed by the windings. The two sleeves are of the same length, and have been constructed to support equal weights, in order to avoid inequality in wearing. The motor-shaft is furnished with pinions which are geared at each end to the car-axle, by which means equal pressures are obtained on the two bearings. This arrangement of the gear-train on each side of the motor was further determined, not only by the great pressure on the teeth, but also by the extremely high tooth speed. This latter amounts to about 18 metres (59 ft.) per second, with a transmission ratio of 147 teeth in the larger wheel to 69 teeth in the smaller wheel. The pitch is 6π mm., and the width of the teeth 100 mm. (4ins.). On account of this high speed it was determined experimentally that it is not sufficient to run the gears in a bath of oil or grease, but it is necessary to feed oil,

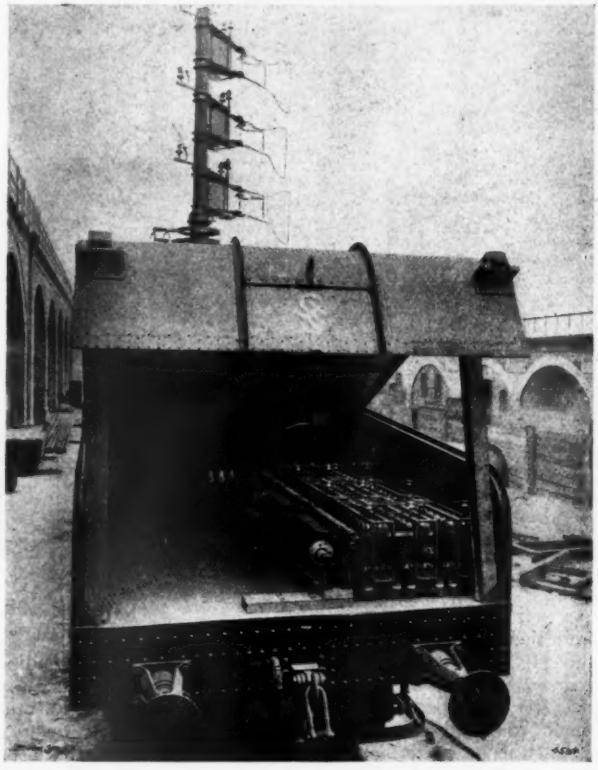


FIG. 4.—AN EXTERIOR COMPARTMENT SHOWING SHEET-IRON COVER RAISED.

under pressure, between the teeth. The locomotive has therefore been provided with an air-pump, producing a pressure of 5 cm. of mercury, which draws oil from a reservoir, through a pipe, to the engineer's valve. Turning this to the right or the left causes a flow of oil to the front or rear of the locomotive (Fig. 7). The oil passes

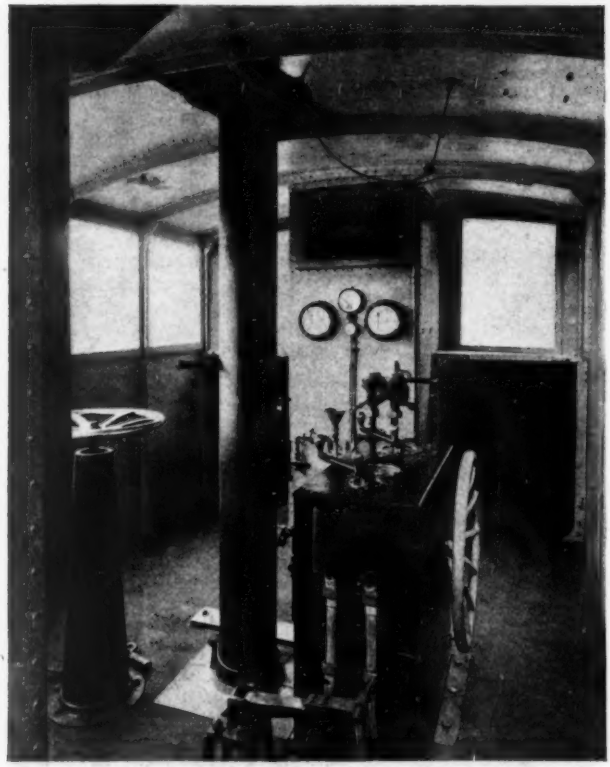


FIG. 5.—THE CONTROLLING APPARATUS.

from the valve in two pipes, flowing into the pipes placed above and below the gears. The oil in this manner enters between the toothed wheels, and falls finally to the bottom of the protecting case, whence it is raised by a pump (driven either by hand or by a motor), and flows into the oil reservoir. This unusual method of lubrication needs only, of course, to be employed for a transmission ratio of 1:2; but if one of 1:35 to 1:4 be adopted, the tooth speeds are lower, and it is sufficient to employ the usual method of lubricating spur-wheels with consistent grease. The gear-box is so arranged that two transmission gears of either 1:2 or 1:35 may find place therein. It is made in the ordinary manner of plate-iron, in two parts, and fastened with specially strong angle-stays to the motor-case. This spur-wheel transmission was the cause of the motors being suspended in the manner usual for street cars and narrow-gauge lines.

The motor case, which is of steel, is cast in two pieces and carefully turned inside, so that the iron laminations, when in place, will be in contact over the whole surface, and a good conduction of heat thus be insured. The bearings, cast in one piece, are furnished with bronze sleeves and white-metal linings. They are 30 cm. (12 ins.) long and 10 cm. (4 ins.) in diameter. In this way it has been possible to reduce the air-gap to 1·5 or 2 millimetres, and to obtain excellent magnetic conditions in the motor. To the case, having an interior diameter of 99 cm. (34·3 ins.), is attached the iron core carrying the primary windings (Fig. 9). The rotor is fixed on the axle by means of a sleeve, in order to provide for supporting the motor directly on the axle, should

it become necessary. The active iron of the rotor, containing the secondary windings, is held together by pressure discs and by a large number of bolts. Another special sleeve, of cast steel, supported on the first, carries the two collector rings, on which rest carbon brushes. An inspection of the interior of the motor can be made through three openings in the case, closed by covers. The motor is lubricated with oil by means of wicks.

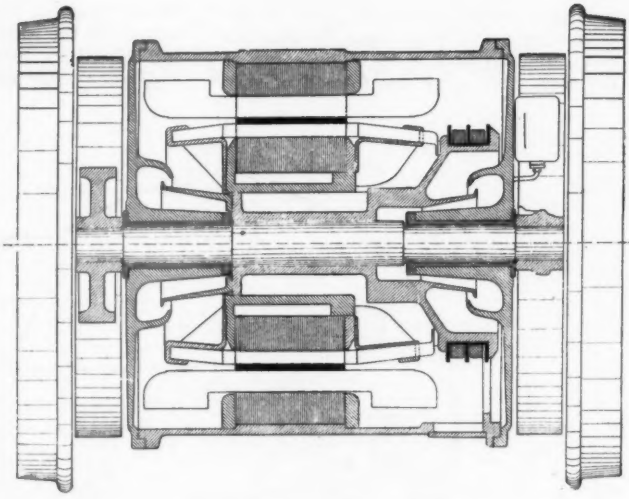


FIG. 6.—SECTIONAL VIEW OF MOTOR.

By this system oil is led up to the place of application by small copper pipes from the special lubricators that are screwed on (see Figs. 8 and 10), an arrangement which became necessary on account of the compact design of the motor. The oil used in the bearings is projected in the ordinary manner by rings towards the oil-catchers in the case, and led over therefrom through apertures in the spur-gear casing. For obtaining better castings the axle-bearings are specially screwed on the motor-case (Fig. 9), while the lugs, which transmit by means of springs the weight and the turning effort of the motor to the truck, are cast in one piece with the case.

It was quite impossible, owing to the high tension, to place the primary windings on the rotor, as was done in the high-speed motor-car, such a method being only admissible for bar-winding.

It was not necessary to construct the motor for a very high turning moment, as, in consequence of the lighter weight of the car, a smaller starting-torque is required. The rotor is therefore of smaller diameter, and the primary winding is placed on the stator. In order to afford

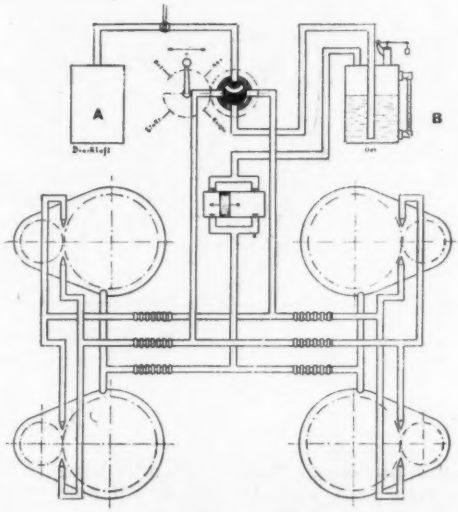


FIG. 7.—DIAGRAM OF SYSTEM OF FORCED LUBRICATION.
A = Compressed Air; *B* = Oil.

as large a cooling surface as possible, the slots were made fairly deep, so that the coils are thin and wide. The cores of the rotor and stator are formed of very thin laminations, those of the rotor being in one piece, while those of the stator are composed of different segments.

A calculation of the windings gave the primary seventy-two open slots, with sixty-seven wires per slot. The coils (former-wound) of the winding are star connected and placed in mica tubes. In order to fully utilise the space, and to secure a very effective insulation, the different coils are placed alternately in long and short tubes, so that the longer ones extend beyond the shorter.

In this way the possibility of short-

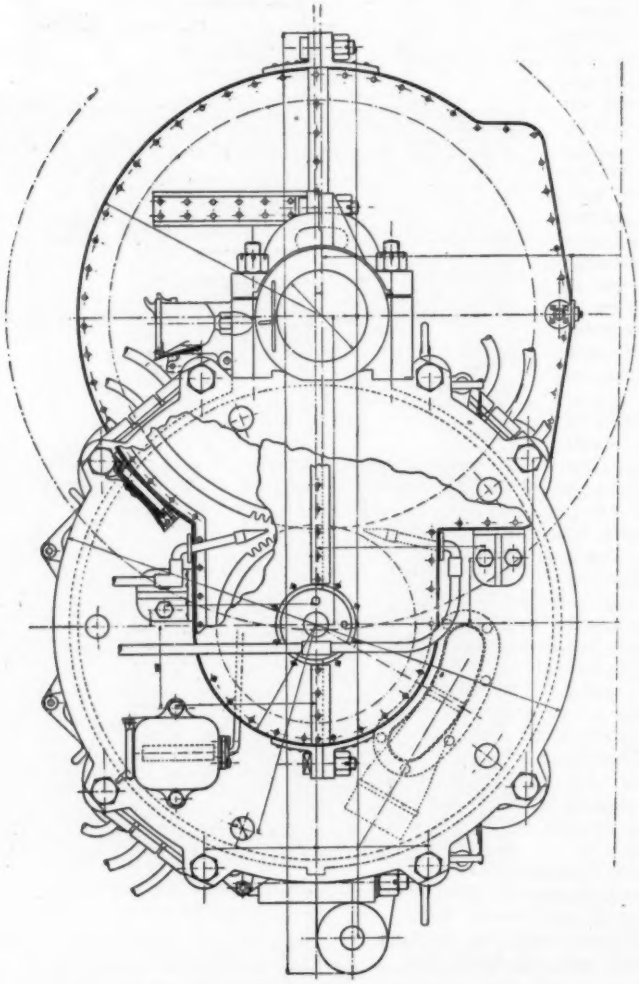


FIG. 8.—ELEVATION OF MOTOR AND GEAR-CASE.

circuiting taking place from one phase to another is appreciably diminished. This method of insulating the high-tension coils was determined after many tests, by which it was shown that the coils withstood a pressure of 22,000 volts without suffering any injury or showing any faults.

The winding of the rotor is placed in ninety semi-closed slots, and consists of flat copper bars, connected in series, with four bars in a slot. The coils of the windings, which are zigzag, are connected in star. Two of the free ends go to the collector rings, while the third is fixed to the core of the rotor. The pressure in the rotor windings is 700 volts at starting. The use of bars for this winding facilitates the application of bronze

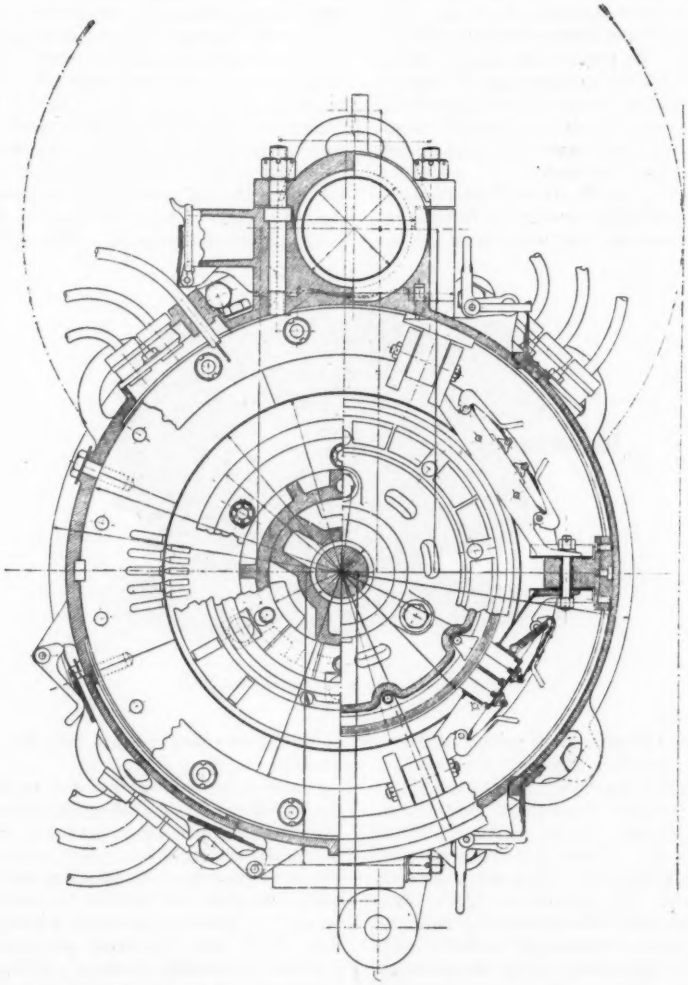


FIG. 9.—SECTIONAL ELEVATION OF MOTOR.

binding-rings, and permits of a very good ventilation. The air which enters about the axle is deflected toward the exterior, through openings provided, by means of strong vanes cast to the core of the rotor.

The velocity of the air is 6 metres per second, and the volume moved 120 litres per second. To prevent the passage of a spark between the bobbins and the case, those parts adjacent to the primary windings are covered by thick layers of mica, and these windings have been kept as far as possible from the case.

The leading of the three high-tension conductors into the interior of the motor has been carried out with great care. They enter through three rubber sleeves, protected in turn by larger ones of ebonite. The insulation of the conductors was made to withstand a tension of 15,000 volts. These porcelain insulators, which in turn are fastened by collars on three iron tubes, are enclosed in mica, so that this place also is sufficiently insulated for a tension of 10,000 volts (Fig. 10). The weight of the motor is 4,090 kilogrammes. The diagram of connections (Fig. 11) shows the course of the current and the apparatus used. The speed of starting is regulated by varying the resistance in the secondary circuit or the rotor. The controller is shown in the diagram as being operated by hand. It is insulated, the third phase of the motor being connected to the earth. The two other secondary phases are connected to two collector rings on the rotor. The current reaches the main switch through fuses in the primary circuit of the motor.

The switch is moved by a piston operated by compressed air, and this serves at the same time as a reversing switch by changing over the phases. Wires to the small conductor branch off through fuses from mains, which are carried to rings on the collecting trolley. The small transformer furnishes, through a switch shown in the diagram, current to a low-tension motor which drives the air-pump. The ammeter and voltmeter are connected in the upper circuit.

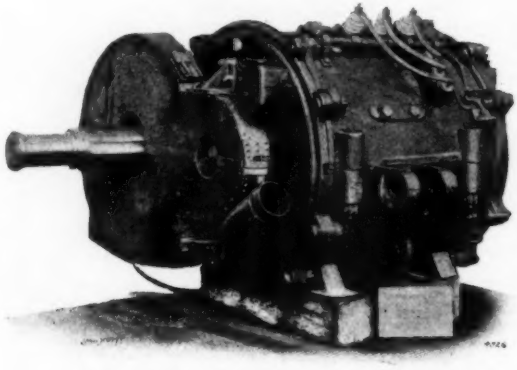


FIG. 10.—EXTERNAL VIEW OF MOTOR AND GEAR-CASE.

Starting the locomotive and regulating the speed are accomplished in the manner indicated by placing resistances in the secondary circuit of the motor, and cutting this out of circuit. Twenty-four resistance coils are provided. The first of these serves to prevent sparking on opening the circuit, and, as well, too heavy a current at starting. These resistances, which consist of spirals of Kruppin wire connected in parallel, are in no way different from those in general use, and are fixed by means of insulators to an iron frame. The controller is of the A B C type, the drums of which are turned by

means of a vertical handle. Manipulation is extremely easy and simple. Throwing the primary winding in circuit, and at the same time changing the direction of motion forward or backward, is accomplished by high-tension switches operated by compressed air. They are placed on the front wall of the driver's cab.

From his table the driver can operate them by means of a valve. The motors are protected by high-tension fuses enclosed in tubes, which are also placed in the ducts just beside the main switch.

A window allows the operation of the controller and the main switches to be watched. The current-collecting apparatus is placed in the centre of the car. It is formed of a single Mannesmann tube, fixed to the floor in a step bearing and supported at the roof by a collar. At the top it bears the three contact bows and springs. The conductors on the roof of the locomotive are bare copper, fastened to porcelain or ebonite insulators. The air necessary to operate this apparatus is compressed by means of a small pump, operated by a 110-volt motor, the current for which is furnished by a small transformer, which reduces the tension from 10,000 volts to that indicated.

The engineer's table is placed in the centre of the locomotive, a little to one side of the longitudinal axis (Fig. 5). The axis of the table is parallel to that of the locomotive, so that the driver, standing before the table, must turn his face to the right or left in order to watch the track. On the table is found the handle for operating the controller. To the left of this table is the switch for the air-pump; to the right, the valve for the main switches, which also reverses the motors. To the right is found the valve for operating the Westinghouse brakes. Before the driver is the pole carrying the bows for collecting the current, which latter can be caused to form contact with, or be removed from the wires by means of a simple handle. The hand brake can be operated by the horizontal handle placed in front of this pole. The measuring apparatus for the pressure of the air, the voltage and current, are fixed on the wall of the cable-way, at such a height that the engineer can easily see them. A place has been reserved for a speed indicator which will be installed in place later, when the speeds exceed 100 kilometres an hour. Below this apparatus is the oil reservoir and hand pump for lubricating the gears.

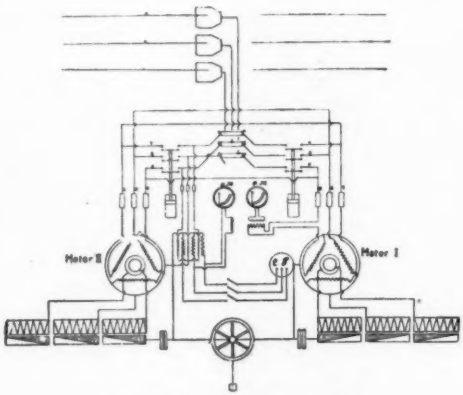


FIG. 11.—DIAGRAM OF CONNECTIONS.

The locomotive was recently tested at speeds from 55 to 100 kilometres an hour, and with frequencies and voltages increasing from 55 cycles and 6,000 volts to 95 cycles and 11,000 volts. These

tests were made in the presence of a large number of officials from the administration of the military railroads and the Studiengesellschaft. A first and second-class passenger car, having four axles and a considerable weight, was coupled to the locomotive, and a maximum speed of 105 kilometres an hour was attained. At this speed the gear-wheels turned without appreciable noise, the motors operating under full voltage satisfactorily. The motion of the locomotive and its trailer was very smooth. The consumption of energy was 260 kilo-watts. This corresponded to a power of 280 h.p., measured at the axle, agreeing exactly with the experiments made at speeds of 100 kilometres. To determine the tractive effort of these motors starting tests have been repeated at different times, as also during the last traction tests. During the tests the locomotive could start with the Siemens & Halske high-speed motor-car attached, giving a total weight of 132 tons in round numbers. These tests have justified the construction of the motors, and have answered an objection made to the application of the transmission of electrical energy for long-distance lines.

They are shortly to be extended to a still higher speed, with the intention of ascertaining the superiority of electric traction over that of steam.

High-Speed Engines.

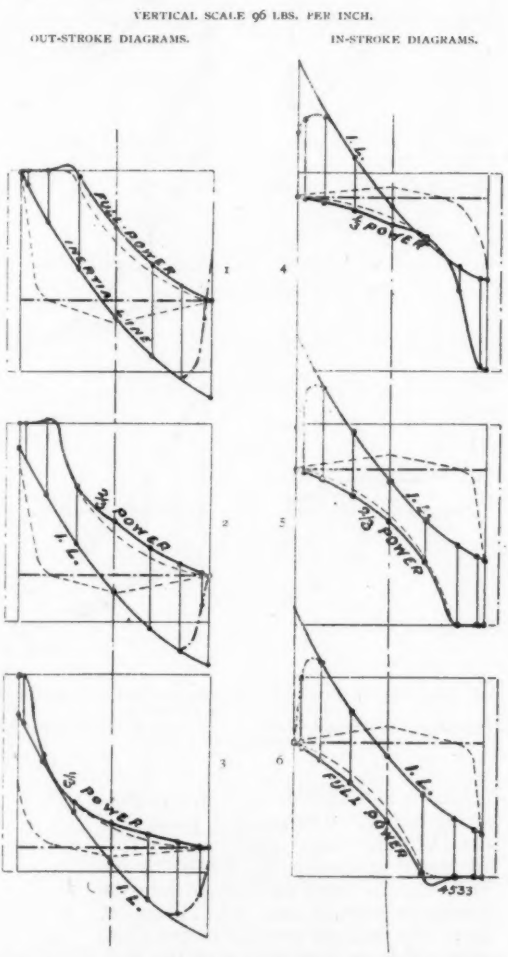
The Influence of Governing on Torque.

By J. H. DALES, A.M.Inst.C.E.

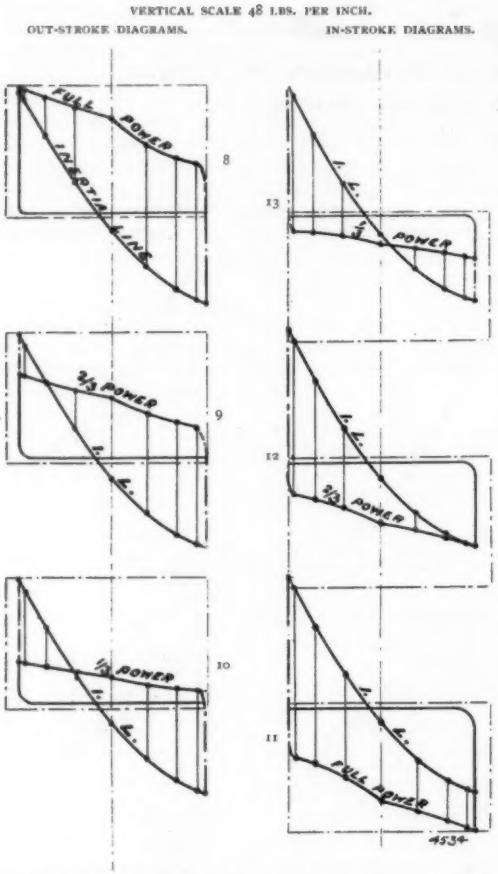
(Continued from Vol. VII., page 314.)

As the majority of compound engines are governed either by cutting off or throttling the steam of the high-pressure cylinder alone, the low-pressure cylinder simply taking the exhaust in either case, these methods of governing only will be dealt with in the following illustrations.

From a glance over the preceding articles on this subject, it is evident that the nature of the turning or torque in the case of cut-off governing will be a compound of the effects of cut-off and throttling, the latter referring of course to the L.P.; and whilst the result is better than all-throttled governing, it will be not so good as single-cylinder cut-off governing. It will be seen further on, however, that such combinations can be made especially with tandem cylinders on one piston-line, as will give results which are unobjectionable even at very high rates of revolution, and this with ordinary arrangements. The steam diagrams, which have been made for purposes of illustration, are of a common type, in which the steam to the H.P. is cut off or throttled, the exhaust passing directly to the L.P. through a passage which partly acts as a compression receiver to the H.P., after the L.P. cut-off, which, in the case assumed, is half-stroke. This is the nearest approach to the Cornish cycle, admittedly the best



FIGS. 1–6.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: HIGH-PRESSURE STEAM AND INERTIA DIAGRAMS.
Piston-Line, 800 lbs. weight; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.



FIGS. 8–13.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: LOW-PRESSURE STEAM AND INERTIA DIAGRAMS.
Piston-Line, 800 lbs. weight; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.

generally, which can be made in a double-acting engine. The terminal pressure of the H.P. and initial steam in the L.P. are made to correspond closely, by the H.P. exhaust being compressed into the passage or receiver after the L.P. cut-off, up to the terminal pressure of the H.P., after which, on the closing of the H.P. exhaust, compression goes on in that cylinder up to the initial H.P. pressure, thus filling and heating the H.P. clearances, and transmitting the H.P. exhaust to the L.P. piston with little diminution of pressure, and so securing maximum economy.

The particulars of piston-line and speed, which are assumed for the purpose of constructing the inertia lines, are similar to those suitable for torpedo boat engines, but applied to high-speed stationary engine proportions of connecting rod, and these are adopted for making the results as clear and striking as possible. The speed taken is 400 revolutions per minute, with a stroke of 18 ins. and a piston-line weight of 800 lbs. each cylinder where taken separately, or a reduction of 20 per cent., 1,280 lbs., where taken combinedly. The piston speed thus works out at 1,200 ft. per minute, which, for the stroke, is high. The connecting-rod is assumed at five crank lengths. A moderate pressure, 150 lbs. per square inch, has been taken to shew what may be done, at an unusually high combined

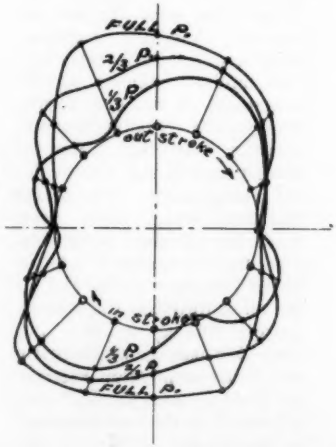


FIG. 7. — CUT-OFF GOVERNING OF COMPOUND CYLINDERS: HIGH-PRESSURE TORQUE DIAGRAM.
400 Revolutions per minute.

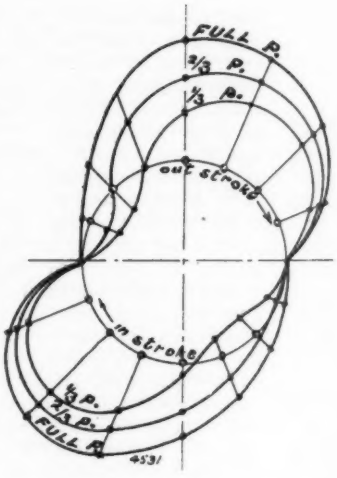


FIG. 14.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: LOW-PRESSURE TORQUE DIAGRAM.

400 Revolutions per minute

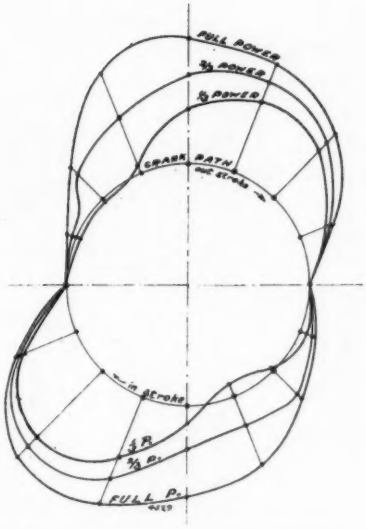


FIG. 15.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: COMBINED HIGH-PRESSURE AND LOW-PRESSURE TORQUE DIAGRAM.

Piston-Line weight, 1,600 lbs ; Crank, 75 ft. ; Connecting Rod, 5 lengths ; Rate of Rotation, 400 per minute.

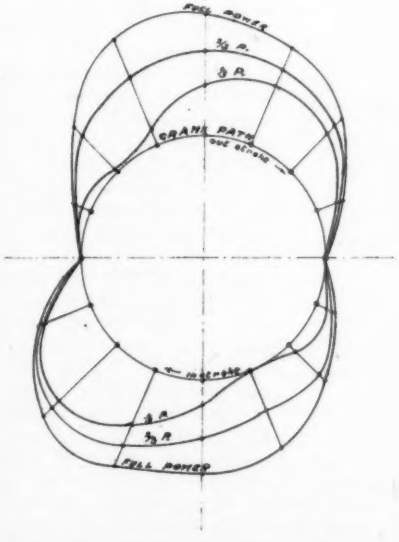


FIG. 28.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: TANDEM COMBINED HIGH-PRESSURE AND LOW-PRESSURE TORQUE DIAGRAM.

Piston-Line weight, 1,280 lbs. ; Crank, 75 ft. ; Connecting Rod, 5 lengths ; Rate of Rotation, 400 per minute.

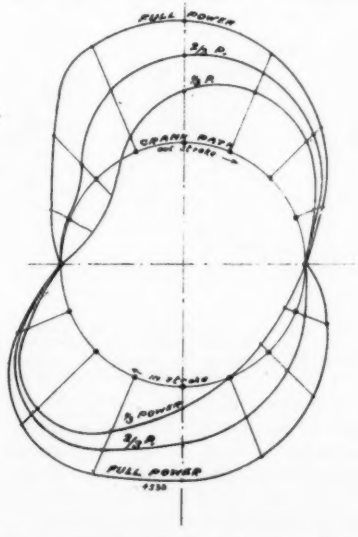
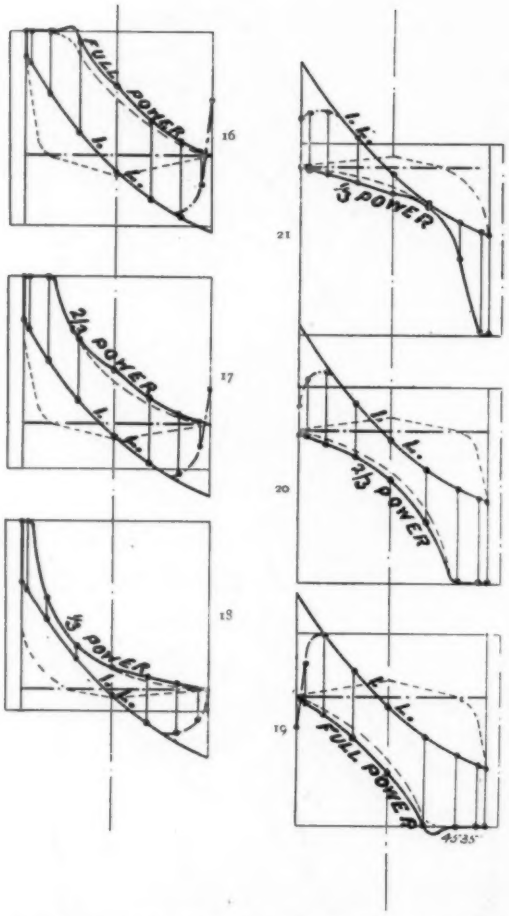


FIG. 41.—THROTTLE GOVERNING OF COMPOUND CYLINDERS: TANDEM COMBINED HIGH-PRESSURE AND LOW-PRESSURE TORQUE DIAGRAM.

Piston-Line weight, 1,280 lbs. ; Crank, 75 ft. ; Connecting Rod, 5 lengths ; Rate of Rotation, 400 per minute.



FIGS. 16–21.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS: HIGH-PRESSURE STEAM AND INERTIA DIAGRAMS.
Piston-Line weight, 640 lbs.; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.

rate of revolution and piston speed, on ordinary lines, by a due adjustment of proportions; and it will be noted that very good running is possible at very much higher than ordinary rates.

The absolute steam pressure is such that with an ordinary and reasonable diameter of cylinder the H.P. initial effective steam pressure of piston-line is, at the commencement of the out-stroke, equal to the inertia of such line, and the diagrams have been worked out to show the general results of such arrangement. The proportions of the cylinders are 1 to 2, the cut-off of the H.P. being arranged to give twice the initial effective pressure of the L.P. to the H.P. piston, so that with equal weights of piston-line the inertia lines and piston pressures are equal at the commencement of the out-strokes at full power. This, it will be seen, is the best turning result, the latter getting well towards the earliest cut-off shown. The same is the case with the throttled diagrams.

The particulars work out as follows:—

·00034 × ·75 ft. × 800 lbs. × 400^2 × 1·2 = 39,168 lbs. for the out-stroke;

·00034 × ·75 ft. × 800 lbs. × 400^2 × ·8 = 26,112 lbs. for the in-stroke;

these being the respective inertias of both piston lines at the commencement of the strokes.

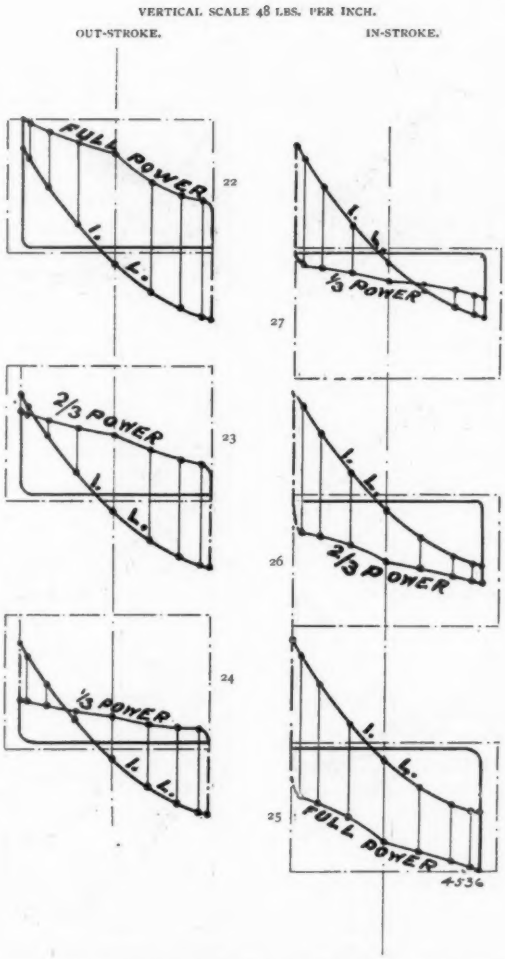
With the assumed 150 lbs. absolute pressure—or, say, 152 or 153, to allow for imperfect vacuum—it is evident that the cylinder proportions would require 100 lbs. effective initial pressure in the H.P. and 50 lbs. effective initial pressure in the L.P., so that if the piston pressure is equal to the out-stroke inertia (39,168 lbs.), and this amount is divided by 100 lbs. the cylinder area would be 391·68 sq. ins., or about 22½ ins. diameter, and the L.P. being required to give an equal result to the H.P. but with 50 lbs. effective, the L.P. piston area would be doubled or 783·36 sq. ins.—about 31¼ ins. diameter.

The weight of piston-line assumed would provide for a sufficient margin of strength.

The plan of this article is to first con-

sider the H.P. and L.P. as separate piston-lines of the weight stated, and to shew the separate torque diagrams as independent lines, say twin compound on opposite crank centres; then to combine these, retaining the same weights, to shew the torque of the shaft or the combined torque as tandem cylinders. After this, to reduce the combined weights 20 per cent. as may be done by a tandem arrangement to shew the improved torque or difference of the same, due to such reduction. Finally, to make a comparison between cut-off H.P governing and throttled H.P. governing, the L.P.'s of course being the same in both cases.

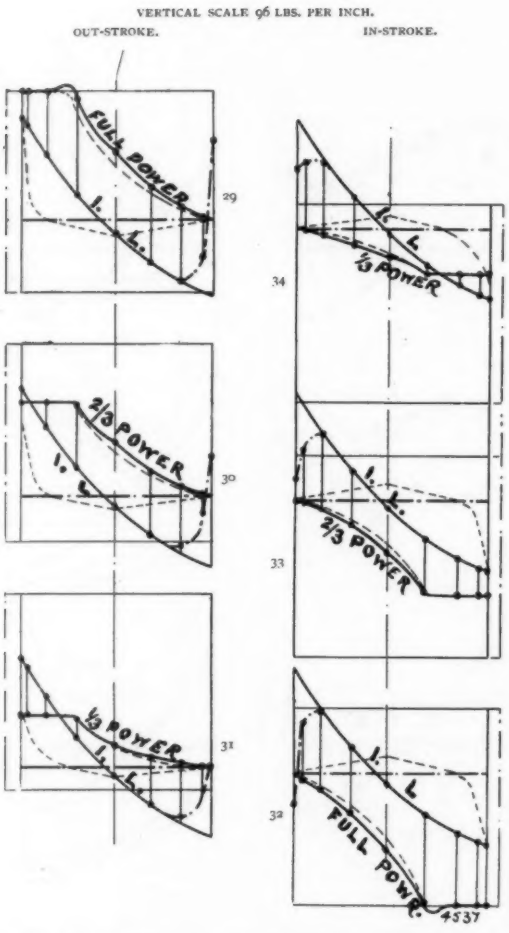
Referring to Figs. 1, 2, 3 and 4, 5, 6, these are steam diagrams, and inertia lines for three cut-offs, each of the in- and out-strokes of the H.P. in which, as before stated, the inertia lines at a scale per square inch of piston corresponds with the initial steam pressure at the commencement of the out-stroke to prevent negative action and knock at that point. The exhaust line of the diagrams is straightened to form a base for the inertia lines, and the expansion curves are raised correspondingly to maintain the vertical steam ordinates. The true steam lines are shewn dotted. It will be seen that the initial pressure increases with early cut-off, in accordance with previous shewing. In only one point in these figures does the steam line become negative to the inertia line, that being in the earliest cut-off shown. The inertia to the commencement of the in-stroke being in this case only $\frac{2}{3}$ of that of the out-stroke, the initial pressure is much higher than the inertia line at that point. Also, by reason of the increase of initial pressure in the earlier cut-offs, the same thing occurs on the outstroke at all points below the full power.



FIGS. 22–27.—CUT-OFF GOVERNING OF COMPOUND CYLINDERS. LOW-PRESSURE STEAM AND INERTIA DIAGRAMS.

Piston-line, 640 lbs. weight; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.

The principle of the effective crank-pressure ordinates and the allowance for compression has been previously ex-



FIGS. 29–34.—THROTTLE GOVERNING OF COMPOUND CYLINDERS. HIGH-PRESSURE STEAM AND INERTIA DIAGRAMS.

Piston-line, 640 × 2 = 1,280 lbs. weight; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.

plained. Fig. 7 is a torque diagram of the H. P., corresponding to the effective crank-pressure lines in Figs. 1, 2, 3, 4, 5, and 6. The full-power line is seen to be very good, and there is no negative effect down to very nearly the $\frac{1}{3}$-power line, where a little takes place on the in-stroke at about $\frac{1}{4}$ stroke of the piston. The full-power line shows a little excessive compression on the in-stroke, making the crank effect slightly negative.

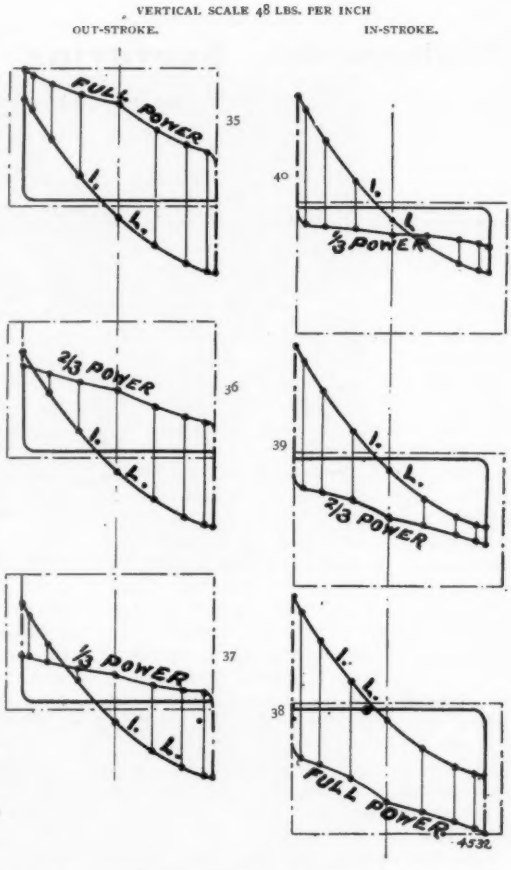
Figs. 8, 9, 10, 11, 12, and 13 are diagrams of the combined steam and inertia effects of the L.P. cylinder, the verticals as before being plus and minus below and above the steam lines respectively. The whole of the out-stroke figures are negative at the commencement of the stroke, below full power; while those of the in-stroke are negative below the $\frac{2}{3}$-power. Fig. 14 is the separate torque diagram for these L.P. figures. The out-stroke lines, with the exception of the full power, are all negative at the commencement of the stroke, which is a bad feature, and those of the in-stroke are only better down to the $\frac{2}{3}$-power line, the $\frac{1}{3}$ power being worse than the out-stroke.

Fig. 15 is a combination of the H.P. and L.P. torque diagrams, which may represent the crank torque of a twin engine, or that of tandem cylinders of the weight of the combined piston-lines. This figure is fairly good, except at the $\frac{1}{3}$-power line, for the forces of which the weight or the speed is just too much. And to show an improvement on this, Figs. 16, 17, 18, 19, 20 and 21 of the H.P., and Figs. 22, 23, 24, 25, 26, and 27 of the L.P. have been made both with a reduction of 20 per cent. inertia by reason of a reduction of weight. The result of these is shown by a combined torque diagram, Fig. 28, which may represent the result of a tandem combination of H.P. and L.P. cylinders, admitting of such a reduction in weight. In this figure no line down to the $\frac{1}{3}$ power touches the inertia line, which is represented by the crank-path circle,

and there would consequently be no negative result in the piston action at any point of the out- or in-strokes.

For a comparison with the foregoing, which are all cut-off governing results, Figs. 29, 30, 31, 32, 33, 34, and Figs. 35, 36, 37, 38, 39, 40, which are respectively out- and in-stroke H.P. throttled diagrams, with similar L.P. figures to the cut-off results, a glance over these figures is sufficient to show the nature of the separate results, and therefore only a combination torque diagram has been made in Fig. 41 for the same reduced weight as Fig. 28. The lines are a sufficient showing of the superiority of the cut-off method for high speeds. The torque is all right down to the $\frac{2}{3}$ power, but below that the result is much worse than Fig. 28. In addition to this, of course the cut-off gives more actual power weight for weight of steam.

It will be seen that it is no easy matter to provide, in a governed engine, those essentials of good mechanical action which are required for high-speed work in the way of balancing the forces at the commencement of the strokes, and thereafter to maintain a positive action of the piston throughout. The first halves of the strokes are the chief points to attend to. In these the steam should in no case fall below the inertia line, and to ensure this the inertia must of course be known. The design of a piston-line is therefore the first step. Any assumed dimension of the small parts will answer the purpose of proportion for any given length. With slight differences, the areas for any required power would be proportionate.



FIGS. 35–40 — THROTTLE GOVERNING OF COMPOUND CYLINDERS. LOW-PRESSURE STEAM AND INERTIA DIAGRAMS.
Piston-line, 640 lbs. × 2 = 1,280 lbs. weight; Crank, 75 ft.; Connecting Rod, 5 lengths; Rate of Rotation, 400 per minute.

(To be continued.)

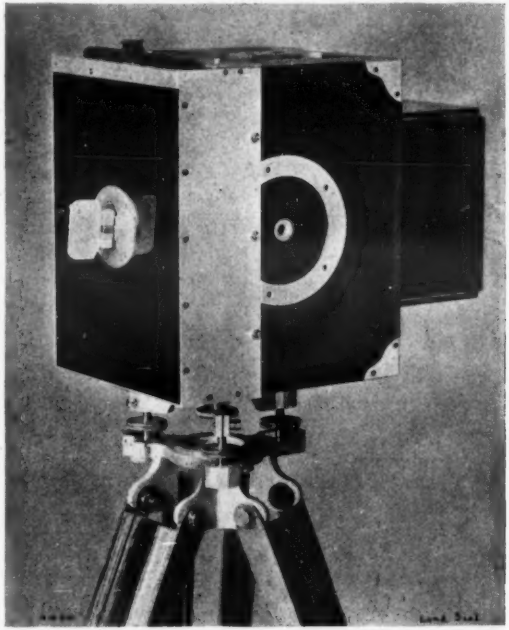
Photographic Surveying.

By J. T. McINTYRE, A.M.Inst.C.E.

(Continued from page 29.)

THE method of plotting by intersections, as given before, only provides for the horizontal projection of points in the landscape, to complete whose position, and to render possible the drawing of contour lines, it is necessary to know their vertical projections above or below a given plane. The plane to which these can most conveniently be referred is the horizon of the picture, and to refer them to sea-level or any other datum it is necessary that the height of the first station occupied above that datum be ascertained by any ordinary method. It will have been noted in horizontally projecting direction rays to points in the landscape that the angles subtended by the same points in the picture projected into the horizon line and the principal vertical plane represent the actual horizontal angles which would be measured on the ground between the same plane and the same points with a theodolite; but a little reflection will show that on a plane projection, such as a photographic negative affords, the only vertical angles between the horizon line and the images of points in the landscape that can be correctly measured are those which fall on the middle vertical. The height of a point falling on the middle vertical can be easily ascertained by measuring its height on the negative or print above or below the horizon, and dividing by the focal length, which will give the natural tangent of the angle of elevation or depression of the object: this, multiplied by the horizontal distance of the point sealed from the plot, will give its height above or below the horizon of the picture. But for points right or left of the middle vertical this rule will not apply, and although spherical and cylindrical plates have been employed to enable its general application these have not proved satisfactory, and the use of plane perspectives is now general. It is obvious that by projecting into the middle vertical the point whose angle of elevation or depression is required, and obtaining a natural tangent, as in the previous case, the natural tangent of the angle actually required can be arrived at by multiplying the tangent just obtained by the cosine of the azimuth of the point from the middle vertical. Or if the point be projected into the horizon and its distance measured from the middle vertical, the perpendicular of a right-angled triangle is given of which the base is the focal distance and the hypotenuse the distance from the station-point to the projection of the point in the horizon. The hypotenuse of this horizontal triangle is the base of a vertical triangle, having for apex the station-point, and the ratio *perpendicular* base gives the natural tangent of the angle of elevation or depression, which requires, as before, to be multiplied by the distance of the point in plan measured from the plot. Or the height may be stated as a fourth proportional to (1) distance from station-point to image of point on horizon, (2) distance from station to point scaled from the plot, and (3) height of image above horizon—a problem which may be solved by one movement of the slide in a slide-rule, or by the section. Any of these methods will suffice, and with the location of the point, as given by intersection, full information of its position in space is now available.

Reed recommends for plotting what he calls a tangent glass, consisting of a glass plate on which are etched horizon and middle vertical lines corresponding with those impressed on the negative. Parallel to these are ruled, horizontally and vertically, a series of lines at distances from



SURVEYING CAMERA AS USED IN CANADIAN SURVEYS.

FIG. 4.—HORIZONTAL DISPOSITION.

FIG. 5—VERTICAL DISPOSITION.

FIG. 6.—SURVEY PICTURE TAKEN WITH SURVEYING CAMERA. THE V-SHAPED FIDUCIAL MARKS WILL BE NOTICED IN THE BORDERS.

the principal point corresponding with the tangents of ½ deg., 1 deg., 1½ deg., and so on, to the radius of the distance line (equivalent focal distance). If the tangent glass be placed over the negative or print and the axes of both made coincident, it is apparent that the angles subtended between points in the view and the middle vertical can be read off by inspection to within six minutes of arc, and more closely by using magnifying power and a finely-divided scale. Instead of using the tangent glass in this way, it could be placed in front of the sensitive plate in the camera, as was done with the réseau or graduated back frame of the camera used in the stereoscopic method briefly alluded to, and impressed upon the same previously to or concurrently with the picture exposure. It will, however, be observed that the method possesses the disadvantages of having to protract the angles and draw rays through them to intersection, which would probably consume more time than the process previously described in detail, while for vertical angles the natural tangents would have to be multiplied by the cones of the azimuths, or a further graphical construction become necessary. A special slide-rule might also be used for the same purpose.

In the execution of photographic surveys various forms of instruments have been employed, and no notice of the art would be complete without a reference to at least the more important amongst them. The ordinary camera has already been mentioned, but it cannot be recommended whenever more precise instruments are available. As constructed from the designs of Werner, some necessary adjuncts are present in the tribrach and levelling screws, spirit-level, and an external horizontal stay between front and back of camera adding somewhat to the rigidity of the apparatus, and tending to ensure verticality of the sensitive plate during exposure. The position of the principal axes are defined by means of triangular metal points in a back frame, which print on every negative, and when joined give the horizon of the picture and principal vertical plane.

More satisfactory is the camera used in the Canadian surveys, of which two views are given, showing horizontal and vertical disposition respectively. In Canada the transit theodolite is used separately from the camera, but both fit on the same tripod. The tripod being set over a station, the azimuths and zenith distances of the triangulation points and of the camera stations are measured with the theodolite; the latter is then unscrewed from the tripod, and the camera fixed in its place. All angular measurements having been made with the theodolite, neither vertical nor horizontal circles are attached to the camera, but it is furnished with direction lines on its upper face and side to indicate the principal planes and field of view of the lens. The camera proper is a rectangular metal box, one end carrying the lens and the other end being open; it is enclosed in the mahogany case shown in the engravings, from which it is kept apart by distance pieces; in the space between the camera proper and the wooden case are fixed two sets of cross levels, read through openings in the outer mahogany box, and permitting the apparatus to be accurately levelled by means of the foot screws, when used either horizontally or vertically. The plate holder, for single plates, is inserted in a carrier, capable of movement backwards and forwards by means of the screw at back, shown in the vertical view of the instrument. During exposure, after the slide has been withdrawn, the carrier is moved forward by means of the screw until the plate is in contact with the open end of the internal metal box; the sides of the latter are notched in the principal axes, the termini of which print out on each negative as small **V**-shaped marks requiring to be joined up in the prints. A survey picture, furnished by the courtesy of Mr. E. Deville, Surveyor-General of Canada, is reproduced (Fig. 6), on which the **V**-shaped fiducial marks indicating the horizon and principal planes will be observed, as well as others, two on each side and top and bottom respectively, making twelve in all, which serve to indicate the axes before-mentioned and the focal length of the lens, as well as permitting test measurement being applied

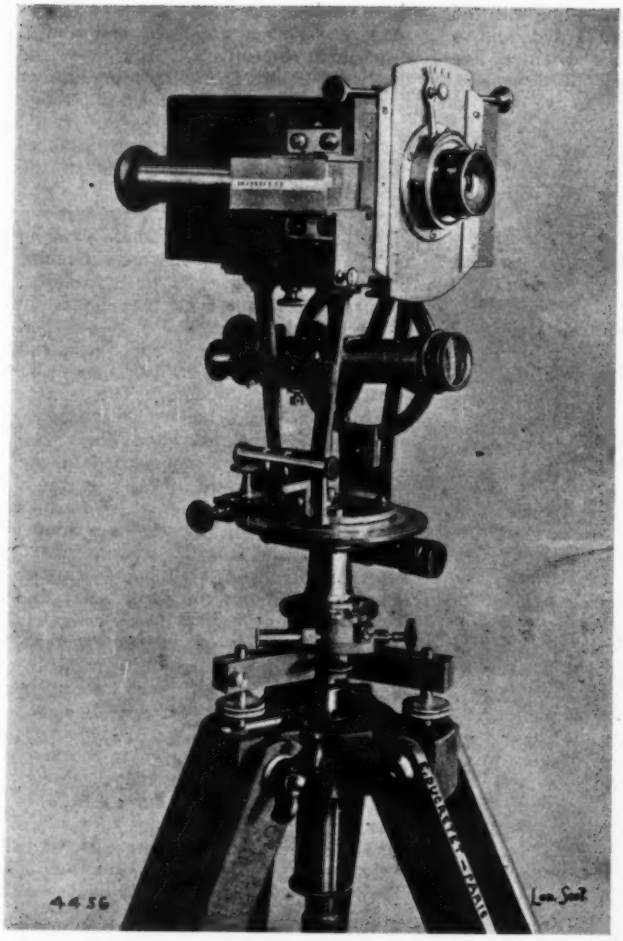


FIG. 7.—COL. LAUSSEDAT'S PHOTO-THEODOLITE

to ascertain if distortion has occurred in washing the prints, or from other causes. The lens is fixed at constant focus, and the focal length for each instrument is ascertained by a simple trigonometrical construction, though more accurately than by the approximate method before described. Once ascertained, it is permanently marked on the open end of the interior metal box so as to print on every negative, and is represented at both top and bottom of every view, the distance from the centre notch to either side notch being equal to half the focal length; the distance between the notches above and below the horizon notches on the sides of the box are equal to one-quarter of the focal length. To ascertain if distortion is present in the prints, the middle notches in top and bottom and two sides are joined up, and the angles tested with a set square; the distance between the upper and lower notches, equal to half the focal length, is taken on the right-hand edge with a pair of compasses and transferred to the left-hand edge. The same distance is then applied at the top of the print from the principal plane on either direction, and should cut the two notches in either hand. The process is repeated on the bottom edge of the print, and if these tests are satisfied the print may be accepted as correct.

A folding shade is hooked on in front of the camera, and with two diaphragms inside the metal box, intercepts all light which does not contribute to the formation of the image on the photographic plate. The lens is a Zeiss anastigmat, No. 3 of

Series V, 141 mm. focus, with a deep orange screen in front. The tripod is a short one, specially designed for mountain work, 3 ft. 4 ins. long, folding to 20 ins., and with camera, base, and case, weighs 14 lbs. 8 ozs. The use of aluminium contributes principally to this result, and to steady the instrument during long exposures a net is secured to the tripod legs, in which a heavy stone is placed. Compared with some of the refined photo-theodolites in European practice, to be presently described, the Canadian instrument is remarkable for its simplicity, and its efficiency is sufficiently vouched for by the fact that a larger area of country has been mapped by its means than with any other instrument yet introduced.

Next in order of importance to the simple camera comes what are called on the Continent "photogrammeters," of which three typical instruments will be briefly referred to, as designed by Messrs. Laussedat, Pollack, and Huebl respectively. The photogrammeter of Laussedat is a light wooden box-camera for plates 9 mm. × 12 mm. or 13 × 18, with wide angle lens by Zeiss, fixed in a sliding front capable of vertical displacement with rack and pinion. The camera is fixed upon a horizontal circle, furnished with a vernier, enabling horizonal angles to be measured; two levels at right angles are provided and three foot-screws, enabling the instrument to be set up level. A back frame, with fiducial points of metal, afford means of indicating the principal axes on the negatives and prints. The maker is E. Ducretet, of Paris.

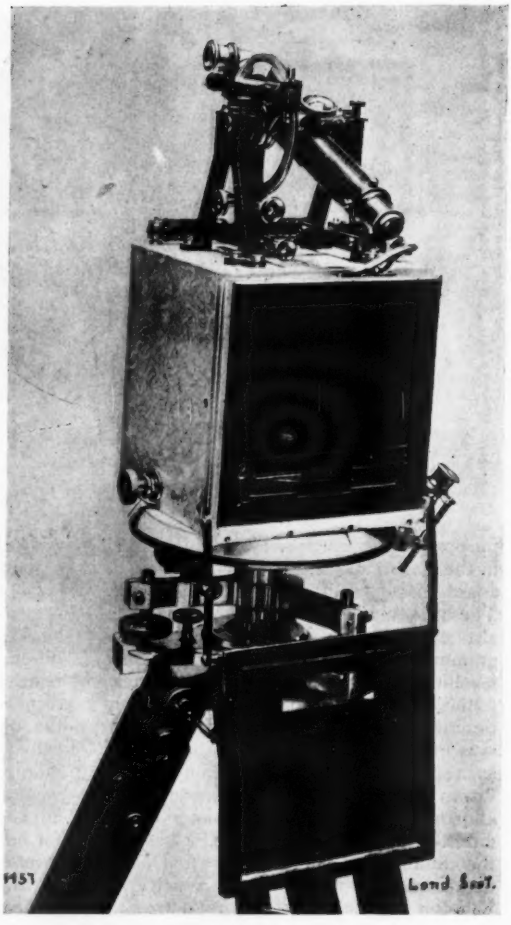


FIG. 8.—THE BRIDGES-LEE PHOTO-THEODOLITE: BACK VIEW.

Pollack's photogrammeter embodies all the features just described, with the addition that the focussing-screen carries an eye-piece with cross threads at the principal point of the perspective, forming, in conjunction with the object-glass, a telescope, thus permitting the principal plane of the picture to be directed towards any given point, and the measurement of vertical angles. On the top of the camera is a compass, and the back frame, in addition to the fiducial marks in the principal axes, carries a series of notches at centimetre distances, which serve the same

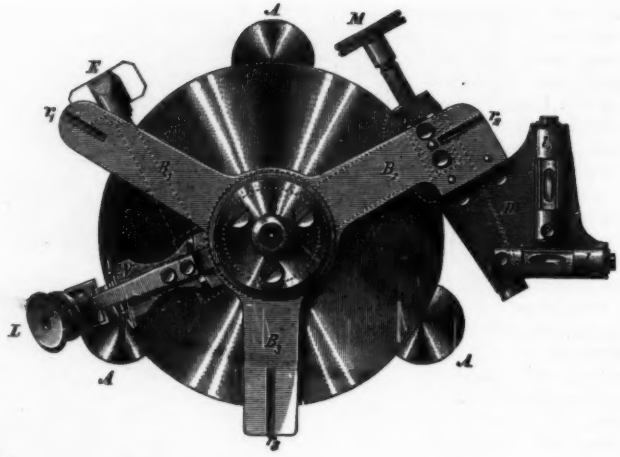


FIG. 9.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: BASE.

purpose as the notches already described in the Canadian camera. The lens is an anastigmat by Zeiss, f. 8, Series V., No. 4. The maker is Lechner, of Vienna, who also makes Huebl's "Plane-table Photogrammeter," an instrument possessing levelling arrangements, graduated backframe, and other attributes previously described; but its principal feature consists in the top of the camera being used as a plane-table, on which azimuths are drawn on a sheet of paper by means of an alidade carrying a telescope and vertical circle. It will be observed that the theodolite and camera are practically combined in this apparatus, which permits the graphic delineation of horizontal angles and the measurement of vertical angles, as well as the formation of photographic images. In the completeness of its range of operations it nearly approaches the class of instruments named photo-theodolites, which may now be referred to. It is in this direction that the greatest diversity exists, and nearly a dozen could be mentioned, embracing wide differences in design. One of the first combined instruments was probably the earlier pattern of Col. Laussedat, in which a camera, somewhat similar to that in his photogrammeter, but with the long side vertical, carried at one side a stadia telescope with vertical circle and striding level. The combination conveys an impression of instability, and in the later model, which is shown (Fig. 7), it will be observed that the telescope is vertically beneath the camera—a more satisfactory disposition. As in the photogrammeter, the objective slide can be moved vertically; but in addition to the focus for infinite distance at which the lens is worked for survey purposes, it can be adjusted for near objects, when required for ordinary photographs, by means of the lever on the front plate. Another feature is the view-finder at the side of the camera, which shows the extent of the view covered by the sensitive plate. The camera is small, accommodating plates 9 mm. by 12 mm. only, of which size fifteen are contained in a charging-box, which can be removed and another substituted in broad daylight. The lens is aplanatic, of 70 mm. focal length; it has an iris diaphragm, and embraces an angle of 60 degs. The telescope transits in its supports, and has complete vertical and horizontal circles. Two levels at right angles are provided, and a tubular compass. The camera can be detached and used upon the same stand for purely

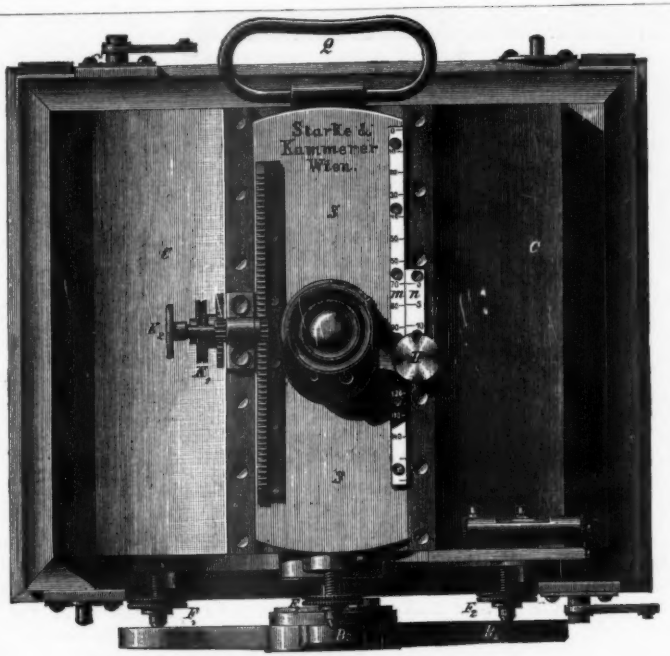


FIG. 10.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: FRONT.

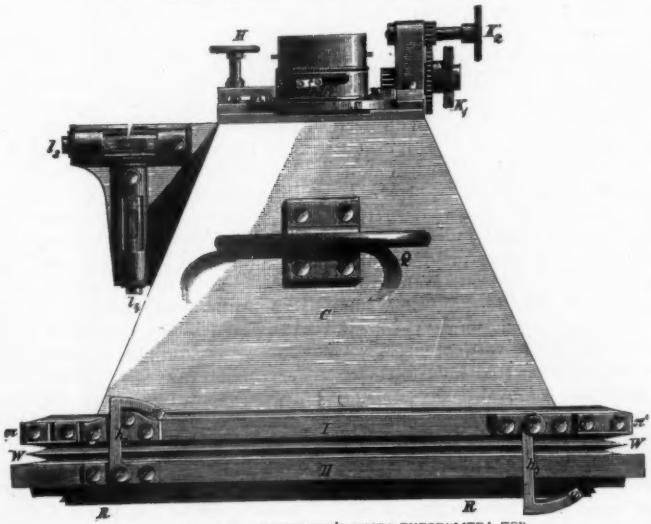


FIG. 12.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: TOP.

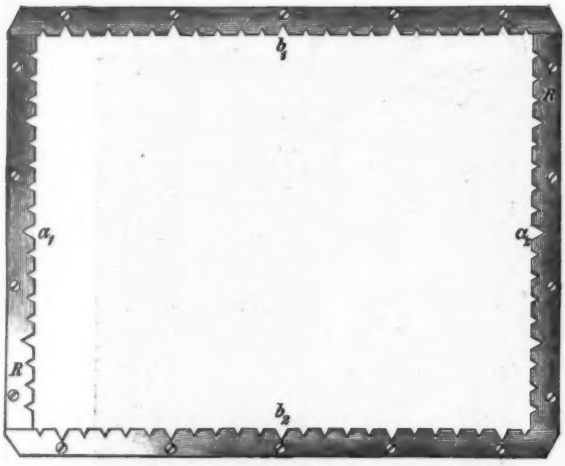


FIG. 11.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: THE BACK FRAME.

photographic purposes; in the same way the theodolite can be used alone when circumstances require. The maker of both instruments is M. E. Ducretet, of Paris.

The photo-theodolite of Pollack resembles his photogrammeter, and includes a telescope with vertical circle, but, unlike Laussedat's earlier model, its weight is not carried by the camera; it is supported by a bent arm pivoted on the vertical axis, and balanced by a counterweight on the other side. Somewhat different to the Continental instruments described is the photo-theodolite of Mr. J. Bridges-Lee, M.A. (Figs. 3 and 8). The most recent model, manufactured by the well-known firm of Troughton & Simms, consists substantially of an aluminium camera upon a theodolite mounting, surmounted by cross levels, and a transit telescope with complete vertical circle. A noticeable difference is that the objective is not mounted in a movable slide, but is rigidly fixed at constant focus in the anterior end of the camera. Another departure is in the back frame, which, instead of being graduated in notches, carries two cross-hairs intersecting in the principal point of the perspective, which are impressed upon every plate exposed, obviating the necessity for ruling lines on the prints. The frame also carries a horizontal transparent scale of angular distances, and pockets for holding strips of transparent celluloid, on which any desired particulars may be recorded, and printed on the negatives and prints. Attached to the back frame is a bottom plate supporting a magnetic compass, with vertical cylindrical transparent scale. These movable internal arrangements are racked backward and forward by means of the milled head screws near bottom of camera, and their position is indicated by the attached pointers. When base plate and back frame are racked forward, the compass needle is automatically lifted off its centre, and when racked back it falls again, and is free to move. During exposure the back frame presses against the sensitive plate, and its attached records, with a portion of the compass scale, print out as shadowgraphs on the negatives and prints, ensuring thereby that each picture bears on its face traces of the horizon and principal plane, compass bearing of the latter, scale of angular distances, and such information regarding magnetic error, barometric pressure, station mark, etc., as may have been recorded on the celluloid strips. The lens has a focus of about 6 inches, and is of rectilinear type, with iris diaphragm. As has already been remarked, the want of knowledge upon photographic surveying which obtains in England is lamentable, and it is surprising that, under the circumstances, so completely equipped an instrument has emanated from an English inventor and an English maker. It, however, stands alone, and for further examples recourse must again be had to the Continent.

In the photo-theodolites just described,

a necessary condition has been that during exposure the camera shall occupy a strictly horizontal position, with the back vertical, high or low objects beyond the field of view being included by raising or lowering the objective slide. In the instruments of the Italian Ordnance Survey and Koppe the camera rotates about a horizontal axis to enable the field of view to embrace necessary details in rocky country. The photo-theodolite of Koppe is a symmetrical and well-balanced apparatus; the lower stage, carrying the levels and foot screws, horizontal circles, and vertical axis, closely resembles the arrangement of a transit theodolite, and the resemblance is continued in the U-shaped support rotating on the vertical axis. The jaws of the U are, however, wider apart than those of the transit, and between them the camera rests on the horizontal axis. The latter projects on either side beyond the U, on one side being the telescope, and on the other the vertical circle with vernier and microscopes and a spirit bubble. Another feature in the Koppe apparatus is the case in which it is transported, which accommodates a number of plates in two boxes in addition to the instrument. It is light-tight, and has two circular holes in front fitted with sleeves of flexible material impervious to light. Having exposed a plate, the camera is placed in the case, which is closed; the hands are thrust through the sleeves, the exposed plate removed and placed in a box, while a new plate is taken from the second box and placed in the camera. The latter is then removed from the case and placed on its supports.

The Geographical Military Institute of Italy uses a pyramidal camera of metal, also capable of rotation about a horizontal axis; but the apparatus suggests the idea of instability, as the telescope and vertical circle, with the bracket which supports them, are all on one side. In a later model the tubular telescope is dispensed with, and the photographic objective takes its place, in combination with an eye-piece in the centre of the focussing screen. Another Italian instrument, intended for rapidly gathering as much topographical information as possible on reconnaissance or rapid work, embraces a box-shaped camera, and, as in the Bridges-Lee instrument, automatically records the compass bearing on each view.

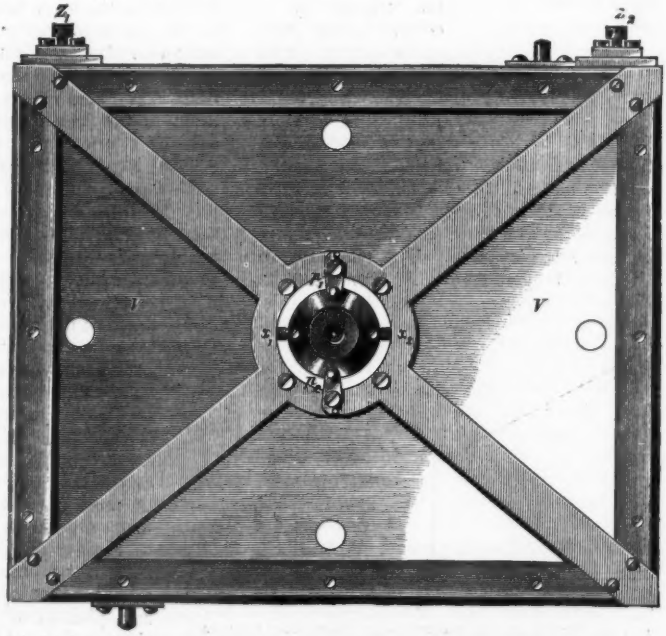


FIG. 13.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: THE GROUND GLASS.

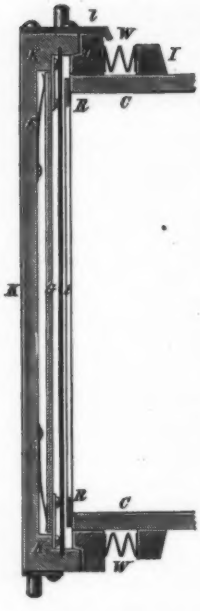


FIG. 14.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: SECTION OF PLATE-HOLDER.

The absence of the auxiliary telescope referred to in the second Italian instrument is also remarked in the photo-theodolite of Starke and Kammerer, of Vienna, a well-designed and refined instrument, illustrative of the best Continental practice. The accompanying illustrations afford every detail of its construction, and with the following remarks will convey a complete idea of its uses:—Fig. 9 shows the base of the instrument, which is secured to the tripod by a central screw and spiral spring. The foot-screws A, A, A of the horizontal plate work in slots in the head of the tripod, and the levels l_1 and l_2 are carried on the plate D at one side. The horizontal circle is divided to 20′ of arc, and reads to single minutes with the vernier N and microscope L. The usual clamp E and tangent-screw M complete its attachments. The tribrach B_1 B_2 B_3 supports the camera (Fig. 10), whose foot-screws F_1 F_2 F_3 rest in the slots r_1 r_2 r_3, and stability is secured by a screw from inside the camera to the lower stage. Cross-levels l_3 and l_4 (Fig. 12) are attached to the camera, which has also a handle at Q for lifting. Fig. 11 shows the back frame R fixed at the focal distance, against which the ground glass and sensitive plate respectively press. The notches a_1 a_2 and b_1 b_2 when joined give the horizon line; the principal plane and principal point of the perspective, and a centimetre scale along each edge furnishes means of testing registration and distortion. The picture measures 17·8 × 22·8 centimetres. The lens is an anastigmat by Zeiss, f. 18 of about 212 mm. focus, secured in the slide S at constant focus with reference to the frame R, in which plane the face of the sensitive plate, the dull side of the ground glass, and the threads of the diaphragm in front of the eye-piece are adjusted. Means are provided for altering the focus to enable near objects to be photographed by means of the helicoidal slit in the outer tube of the lens and a small block screwed to the inner tube. The slit allows for a total movement of the lens in the direction of the axis of 2 mm., and as the interval is divided into twenty parts, it is possible to read the displacement to $\frac{1}{10}$ of a millimetre. In practice, the index is generally set at zero, and the lens clamped in that position, for with a lens of 212 mm. focus, the displacement of the focal plane for distances of 500, 400, 300, 200, and 100 metres respectively, should be only 0·09, 0·11, 0·15, 0·22, and 0·45 mm., and as in photographic surveying more objects will generally be beyond 500 m. than within that distance, no adjustment is necessary. Should, however, special circumstances necessitate it, the range of motion (2 mm.) will bring in focus objects as near as 23 metres to the instrument. The objective slide S has considerable range of displacement by means of the rack and pinions K_1 K_2, the latter for slow motion, while H is the clamp.

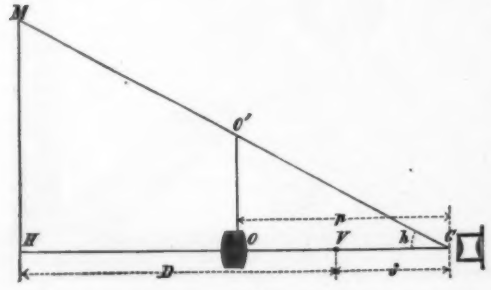


FIG. 15.—STARKE AND KAMMERER'S PHOTO-THEODOLITE: DIAGRAM SHOWING METHOD OF USING.

The displacement is read on a scale *m* divided to millimetres, with the vernier *n* reading to 0·05 mm.; the scale is 140 mm. long. From 0 to 70 the optical axis is directed below the horizon, and from 70 to 140 is directed above; at 70 it should be exactly on the horizon.

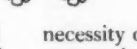
Fig. 12 illustrates the light-tight connection between the camera and plate-holders or ground glass, which is effected by means of two frames, *I* and *II*, with the bellows *W*. *I* is fixed to the camera, but *II* can move as far as the bellows extend. Each frame carries two hooks; the frame *I* has the upper right one, h_1 and an exactly similar one, lower left. The frame *II* has the upper left hook, h_2 and a lower right one. These hooks fasten the ground glass and plate-holders to the camera. The ground glass is shown in Fig. 13; in Fig. 14 it is represented in section attached to the camera. The outer wooden frame carries two metal diagonals connected to a central ring. In the middle of the ring is the eye-piece, movable on the axis x_1 x_2, but which may be fastened by the two flaps p_1 p_2 in its normal position, with the optical axis perpendicular to the ground glass. Opposite the notches a_1 a_2, b_1 b_2, of the back frame are circular openings in the ground glass, through which the notches may be examined for adjusting the instrument. In attaching the ground glass, frame *II*, which does not come into operation, is fastened to frame *I* by the upper left hook h_2 and the lower right one. The ground glass is supported by the screws Z_1 Z_2 (Fig. 13), the points of which rest on the plates of the fixed frame *I*. The face of the glass is then brought into contact with the back frame through the upper right and lower left hooks. The position of the eye-piece is adjusted by the screws Z_1, Z_2, until "the line" of collimation is horizontal, when the object glass is in its normal position at 70 of the vertical scale. In this position, or not far from it, points can be sighted through the eye-piece of the ground glass, but when the lens is further away from the normal position, the use of the eye piece with its axis perpendicular to the ground glass becomes inconvenient; accordingly the flaps p_1 p_2 are unfastened, and the eye-piece is rotated on its axis x_1 x_2 until its optical axis is in the direction of the object-glass. The plate-holder *K*, shown in section, Fig. 14, contains the sensitive plate *G*, pressed by springs at the four corners; the hard-rubber shutter *t* is completely withdrawn during exposure. The adjustment of the plate-holder to the camera takes place in the following manner:—Frame *II* is set free from *I*, and the holder hung on frame *II* by the bent plate *l*; the projecting edge of the holder engages in the rebate of frame *II*, and makes a light-tight joint. It is then fastened to frame *II* by the pair of hooks, upper left and lower right; Fig. 14 shows this position of the holder. Having made sure that the cap is on the lens, the shutter is now withdrawn, after which the pair of hooks, upper right and lower left, are brought into play, and draw the holder forward until the plate is brought in contact with the back frame *R* of the camera. After giving the exposure by uncapping the lens, the holder is withdrawn by repeating the same operations in inverse order. Where the camera has been set up at a triangulation point or station whose position is known, the only angles to be measured are horizontal angles on to known points, to permit of orientation of the view; but it will sometimes happen that in order to include necessary features, the camera has been set up as a subsidiary station, in which case vertical angles on to known points in the triangulation will be necessary to fix the altitude of the subsidiary station. The photo-theodolite of Starke and Kammerer provides for this in the manner shown in Fig. 15. Let *O* be the second nodal point of the lens, *C* the intersection of the diaphragm threads; the instrument being adjusted, *C O* is horizontal when the lens is at 70 of the vertical scale. Let *M* be a known point from which the position of the photographic station must be ascertained; *H M* is the altitude to be found. The eye-piece is turned in the direction *C M*, and the object-glass raised until the image of *n* is seen at the intersection of the threads of the diaphragm; the objective slide is then clamped, and its

height read on the vertical scale. Let v be the intersection of the vertical axis of the instrument with the horizontal axis of the camera. In the triangles $M\ H\ C$, $O^1\ O\ C$, the distance s must have been previously ascertained; $O\ O^1 = h$ has been measured on the vertical scale, $O\ C = p$ is the focal length, and δ is a constant of the instrument which can be scaled on it. These two similar triangles give the proportion $\frac{H}{h} = \frac{D + \delta}{p}$, H being the difference of altitude $H\ M$. Therefore $H = \frac{h}{p}(D + \delta) = \frac{h}{p} D + \frac{h}{p} \delta$. For this instrument $\delta = 100$, $p = 212$ mm., and a maximum value of h is 70 mm. Then $\frac{h}{p} \delta$ cannot exceed 0·33 mm., a quantity which can always be neglected, the expression of H taking the simpler form of $H = \frac{h}{p} D$.

The variety of instruments employed, from which the foregoing examples represent a selection only, will afford an indication of the extent to which photographic surveying has been pursued outside Great Britain. Of its practical utility it is unnecessary to adduce proof in view of its extensive adoption in Italy and in Canada and other countries; and it is to be hoped that wider publication of its principles, application, and possible uses, may tend to its wider adoption.

A Method of Determining the Temperature of Exhaust Gases.

By R. H. FERNALD, A.Am.S.Mech.E.



In preparing detailed specifications and instructions for conducting tests of gas-engines, the attention of the writer was directed to the necessity of an accurate and inexpensive method of determining the temperatures of exhaust gases, the result of his investigation being presented before the American Society of Mechanical Engineers in a paper, of which the following is the text.

This problem has apparently received little attention, at least not sufficient to develop any simple means of making accurate determinations. In cases in which the results seemed to be reasonable, the apparatus used was far too expensive or too delicate for ordinary conditions, and efforts were at once centred upon the desired solution.

In the books at hand on engine tests, no mention is made of any method, and even in the very recent report of the committee appointed by the American Society of Mechanical Engineers "to codify and standardise the methods of making engine tests," the committee says (Paragraph XX.): "The computation of temperatures corresponding to various points in the indicator diagram is, at best, approximate. It is possible only when the temperature of one point is known or assumed, or when the amount of air entering the cylinder along with the charge of gas or oil, *and the temperature of the exhaust gases are determined.*" In the fine-print detailed instructions under the same paragraph the report states, "*T*' may be taken as the temperature of the exhaust gases leaving the engine, provided the engine is not of the 'scavenging' type."

Again, in referring to the value represented by *T* in formula *B* of the same paragraph is found the expression, "If *T* be the observed temperature of the exhaust gases."

While references thus made indicate the necessity of obtaining these temperatures, yet nowhere in the report is there any suggestion of a method of making these determinations. Even if pyrometers and thermometers are regarded as sufficiently accurate, yet no measurements made at or near the muffler can give the true temperature of the exhaust gases unless proper corrections be made for the fluctuation in pressure. This at first appears to present little difficulty, but more careful thought shows the fallacy of the first impression.

Consider for a moment the action taking place at the opening of the exhaust. Although the gases in the cylinder have undergone rapid expansion after explosion, yet the expansion is far from complete, and at the point of release the pressure is still relatively high, as shown by a glance at Fig. 1.

At the instant the exhaust opens, there is an outrush of gases at this high pressure and correspondingly high temperature. Then follows, upon the forward stroke of the engine, a flow of a large mass of gases through the exhaust port, at a pressure little above that of the atmosphere and at a temperature necessarily less than that of the first discharge. In order to make the succession of events more apparent an indicator was attached directly to the exhaust-pipe, and the cards obtained, as shown in Figs. 2 and 3, verified the statements just made in regard to the action taking place within the pipe. The diagrams represent the same conditions, the spring used for Fig. 2 being only one-half as heavy as that used in Fig. 3.

There is, as it were, a mixture of pressures in the exhaust-pipe and muffler, and also a corresponding mixture of temperatures, which must rapidly adjust themselves to an equilibrium of pressures and of temperatures.

Temperatures determined at the muffler

FIG. 1.

are, therefore, not the temperatures corresponding to the pressure at exhaust, but those corresponding to a much lower pressure, which is not determined. This accounts, no doubt, for the very low values of exhaust temperatures which have been reported, even by recognised authorities upon gas-engine problems.

The problem, therefore, resolves itself into the determination of the temperatures of the exhaust at some known pressure. As a matter of simplicity, atmospheric pressure was the natural selection, and a method was at once sought for reducing the exhaust gases to atmospheric pressure without losing any of the heat to which they are entitled.

It was at once decided that a receiver, of a form to be determined, should be placed close to the exhaust outlet of the engine, and some means devised for admitting the exhaust gases and allowing their pressure to fall to that of the atmosphere. The desired temperature could then be ascertained.

What the form of the receiver should be was not at first apparent, and as practically no information could be found bearing upon the subject, the problem was reduced to one of experiment.

The first steps in the development were necessarily very crude, and the results were of value only as furnishing a basis upon which to judge future determinations, and as such were of great value.

The first experiments were conducted as follows:—Two cylinders of sheet-iron

FIG. 3.

were made, one 10 ins. in diameter and the other 14 ins.; they were 16 ins. high. The 10-in. cylinder, after being generously perforated near the bottom, was placed inside the 14-in. cylinder, the latter having several deep notches cut out at the top. A cover of the same material, and 15 ins. in diameter, was made, with a central hole about 2½ ins. in diameter, through which the exhaust-pipe from the engine could be passed. A T was placed as close to the exhaust outlet of the engine as possible, and from it one line of pipe was run directly to the exhaust-muffler, as usual, and the other line brought out horizontally and at right angles to the first, and then directed downward to the receiver just described, the end of the pipe projecting about 2 ins. through the cover into the inside cylinder. Fig. 4 gives a rough idea of the arrangement.

Valves were inserted in both pipes, so that the passage of the gases to the

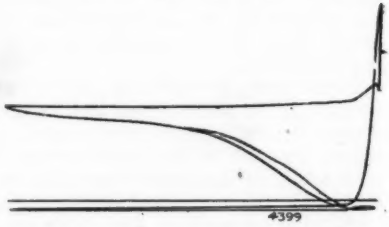


FIG. 2.

receiver, or to the muffler, or to both at once, could be regulated at will.

In the receiver the gases were passed downward through the inside cylinder, out through the perforations and upward between the two cylinders, finally passing out through the notches in the top of the outside cylinder. The object of this arrangement was to prevent any direct draught or chimney action which would cause an inrush of cold air at the bottom as soon as the inlet-valve was closed. Two holes, large enough to receive the thermometers, were punched in the cover, one midway between the centre and the inner wall and the other about half an inch from the inner wall. There was no expectation that temperatures even approaching

correctness could be obtained by this arrangement, but such a preliminary step was essential in order to have values with which future results could be compared.

The exhaust was directed to the receiver, and after being allowed to flow until the cold air in the receiver was entirely expelled, was shut off, and the thermometers quickly inserted. The gases were now held in the receiver at atmospheric pressure. The pressure, before closing the inlet, was much greater, but dropped almost instantly to that of the atmosphere when the valve was closed. The difference in the readings of the two thermometers, one near the wall of the cylinder and the other about 2 ins. from the wall, was not sufficiently marked to be of importance. The temperatures observed were :—

370 degs. Fahr.	394 degs. Fahr.	398 degs. Fahr.
395 ,,	372 ,,	400 ,,
—	370 ,,	—

Various problems were now to be considered. Radiation and conduction from the cylinders to the outside air might be so rapid as to vitiate the results. The thermometers might be affected by radiation from the inside walls. Radiation from the iron exhaust pipe, which projected into the cylinder, might make the readings too high. Longer runs might tend to cause the cylinders to store up heat.

Many such difficulties had to be considered, and, no data being found bearing directly upon the subject, the experiments were continued.

An asbestos lining was now placed in the outside cylinder, and the temperatures obtained were :—

474 degs. Fahr.	511 degs. Fahr.	525 degs. Fahr.
540 ,,	552 ,,	517 ,,

Evidently the gases were retained at a much higher temperature than before; but were these higher temperatures due to excessive storing up of heat, or simply to the prevention of excessive radiation? A similar lining was also placed in the inside cylinder, and the temperature immediately shot up to over 600 degs. Fahr., which was unquestionably far too high. In all of the above experiments radiation through the cover was prevented by an asbestos lining.

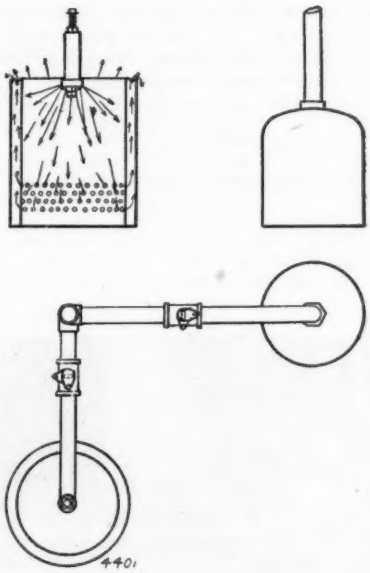


FIG. 4.—SHOWING ARRANGEMENT OF APPARATUS WITH WHICH THE EARLIER EXPERIMENTS WERE CONDUCTED

After considering cylinders of various materials, a clay fire-flue 10 ins. in diameter

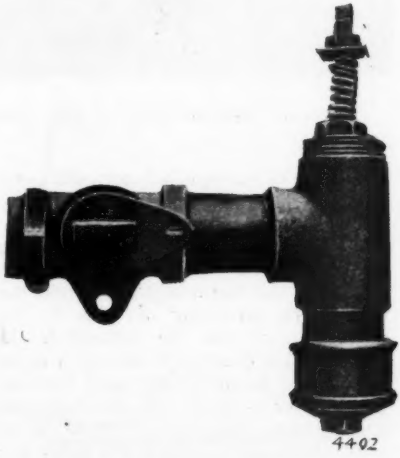


FIG. 5.—THROTTLING DEVICE.

was secured and used in place of the inner iron cylinder; the outside iron cylinder, with its asbestos lining, being retained. The temperatures now recorded were:

360 degs. Fahr.	484 degs. Fahr.	585 degs. Fahr.
388 ,,	498 ,,	560 ,,
405 ,,	512 ,,	564 ,,
442 ,,	541 ,,	554 ,,
465 ,,	552 ,,	569 ,,
469 ,,	554 ,,	576 ,,
—	567 ,,	—

These figures seemed to indicate a gradual storing of heat from the first to about 560 degs. Fahr., when the readings became more constant, but not sufficiently so to warrant the conclusion that the apparatus was nearly correct.

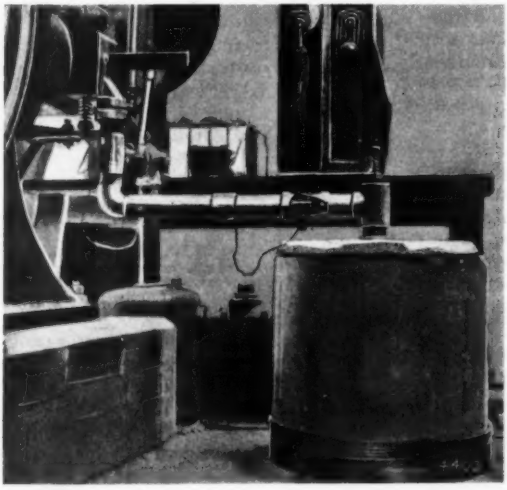


FIG. 6.—COMPLETED RECEIVER ATTACHED TO ENGINE.

The conclusions at once reached were that the volume for the gases was too small, and the thermometers too near the walls. The absorbing of heat by the receiver must also be prevented. In studying this problem it was seen to be undesirable to allow the gases to enter the receiver at such high pressures and temperatures, and that it would be of great advantage to admit the gases at a pressure and temperature little above those desired at the time of reading the thermometers. This would do away, to a large extent, with the tendency of the receiver walls to store up heat, as at no time would they be excessively heated.

The proper throttling was secured by the device shown in Fig. 5. It consists of a 2-in. T, with a plug in the top, through which passes a $\frac{1}{2}$-in. bolt, and a nipple and cap in the bottom. The bolt is supported by a helical spring, and in turn supports at the bottom a flat iron disk which rests against the 2-in. cap —the bottom of the cap being freely perforated.

By screwing down the nut at the top, against the spring, any desired resistance to the passage of the gases can be obtained, and at the same time any tendency to wire-drawing is obviated, as would not be the case if the throttling were done by means of the valve in the pipe alone.

Before experimenting to any extent with this device for reducing the pressure, a new clay fire-flue, 18 ins. in internal diameter, with cover of the same material, was obtained. In order as far as possible to prevent any radiation to the thermometer from the iron pipe delivering the gases to the receiver, the lower end of the device was allowed to pass barely through the cover, extending not over an inch below the inner face.

The bottom of the receiver was notched in several places to allow free passage of the gases from within. The gases were thus received at the top, passing downward and out at the bottom. A rubber band 3 ins. wide was bound about the bottom of the receiver, thus acting as a flap-valve, the pressure of the gases entering the pot forcing the band outward, but the falling of the band preventing any inrush of cold air when the admission of the exhaust to the receiver was stopped. In Fig. 6 is shown the completed receiver as attached to the engine.

Many series of experiments have been carried on by means of this device with most satisfactory results. With the feed so adjusted that the exhaust entered the receiver at a pressure but little above that of the atmosphere, the storing of heat in the walls was practically prevented.

In case the exhaust was delivered to the receiver for an hour or more without ceasing, there was a slight rise in temperature, but, as in practice, the exhaust is cut off about every ten minutes no difficulty is experienced from this cause.

The pressure under which the exhaust enters the receiver does not have to be closely regulated, as a slight difference does not affect the resulting temperatures when taken at atmospheric pressure.

Especially satisfactory results have been obtained when the pressure was so regulated that the temperature of the gases in the receiver, while under pressure, was between 50 degs. and 100 degs. above the temperature at atmospheric pressure.

One or two preliminary tests will quickly determine what this temperature should be. The temperatures recorded from the new receiver did not range from 400 degs. Fahr. to over 600 degs. Fahr., but were :

200 degs. Fahr.	202 degs. Fahr.	203 degs. Fahr.
195 ,,	201 ,,	200 ,,
195 ,,	203 ,,	200 ,,
—	203 ,,	—

The radiation from the receiver was not large. The walls were 1 in. thick, and the hand could at all times be held on the outside.

Any change in the conditions tending to change the temperatures of the exhaust is quickly noticed by a corresponding change within the receiver. For example, if the point of ignition be changed, a corresponding change in temperatures is immediately observed. With the point of ignition, as shown by the diagram, Fig. 7, the following temperatures were recorded :

199 degs. Fahr.	197 degs. Fahr.	197 degs. Fahr.
198 ,,	196 ,,	198 ,,
198 ,,	196 ,,	198 ,,
—	199 ,,	—

With the ignition retarded as shown by Fig. 8, the temperatures were :—

210 degs. Fahr.	210 degs. Fahr.	207 degs. Fahr.
216 ,,	212 ,,	212 ,,
214 ,,	211 ,,	209 ,,
—	210 ,,	—

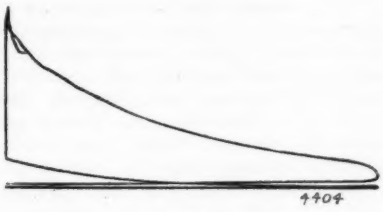


FIG. 7.

FIG. 8.

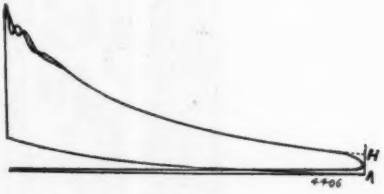


FIG. 9.

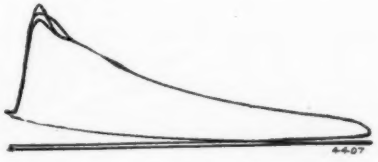


FIG. 10.

FIG. 11.

While making this particular series of experiments on points of ignition, the engine became stalled when set for a certain point of ignition, and refused to run. The igniter was removed, and found to be badly burned. It was adjusted for sharper contact, and a new series of readings taken.

An immediate drop of about 50 degs. in the temperature resulted, showing at once the quick response of the receiver to changed conditions. The spark was now sharp and short, while previously the condition of the sparker was such that it was "holding fire."

The new series on the variation of the point of ignition shown in the diagram resulted as follows, the temperatures in each column corresponding to the point of ignition shown in the diagram, having the same number as the column of temperatures :—

For Fig 9.	For Fig. 10.	For Fig. 11.
151 degs. Fahr.	166 degs. Fahr.	172 degs. Fahr.
149 ,,	168 ,,	176 ,,
151 ,,	168 ,,	178 ,,
152 ,,	167 ,,	175 ,,
152 ,,	167 ,,	178 ,,

Owing to the size of the receiver, and to the necessity of having other connections made to the engine, the exhaust pipe leading to the receiver was longer than desired, having a drop of about 1 ft., and a horizontal length of 27 ins.

The question of the necessity of covering the pipe, to prevent excessive radiation in conducting the hot gases to the receiver, was quickly settled by the following temperatures obtained :—

Covered.	Not covered.
155 degs. Fahr. ...	160 degs. Fahr.
155 ,, ...	158 ,,
154 ,, ...	158 ,,
156 ,, ...	155 ,,
158 ,, ...	156 ,,
158 ,, ...	157 ,,
158 ,, ...	156 ,,
160 ,, ...	157 ,,

Having become satisfied that the apparatus, as outlined, was working with a reasonable degree of accuracy, the next step was to devise a receiver which can be erected quickly and cheaply, as it is not always convenient to procure a fire-flue of the right size. Accordingly, a receiver was built of ordinary brick, laid together loosely, as shown in the cut, Fig. 12.

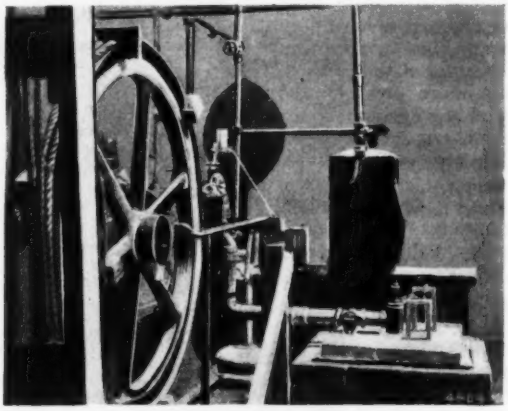


FIG. 12.—DETERMINING THE TEMPERATURE OF EXHAUST GASES.

This receiver was made of two layers of brick, the inside layer being laid on the face and breaking joints, the outside layer being laid on edge, thus breaking joints both vertically and horizontally with the inner layer. While the cracks furnished sufficient passages to prevent any overcharging of the receiver, yet the breaking

of the joints prevented direct draughts or inrush of cold air. As first constructed the volume of the new receiver was made equal to that of the 18-in. fire-flue previously used, and the fire-flue cover was fitted to the new receiver. The results were highly satisfactory, the temperatures being the same as before.

The interior was then partially filled with brick until the volume was reduced from 16 by 16 by 23 to 16 by 16 by 13, and again tested with the same results.

In all of these tests with the two larger receivers the thermometer bulbs were kept about 4 ins. to 7 ins. away from the walls and from the entering pipe. In the last receiver, when partially filled with brick, the thermometer bulbs were placed about the same distance from the cover and the bottom.

It seems unnecessary, therefore, to have excessive volume, but there must be sufficient space so that the thermometer bulbs shall not be too near the retaining walls. Experiment indicates that the figures suggested for these distances are about right.

During the test the valve leading to the muffler in the main exhaust is kept wide open, unless the exhaust pipe is larger than is needed for the quantity of exhaust, and the valve in the pipe leading to the receiver is opened as desired. It is necessary to expel fully the cold air in the receiver before any readings can be taken. With the larger receiver and an 8-h.p. engine this required about 20 mins. The time can be much reduced, when desired, by careful manipulation of the valves after one becomes familiar with the apparatus.

It is of great value to keep suspended within the receiver at all times a thermometer of sufficient range not to be broken by accidental increase of temperature. In the initial warning of the receiver, this thermometer will readily show when the temperature has become constant. It also serves as a very efficient guide in adjusting the pressure as controlled by the inlet. For most of the readings taken the pressure was so regulated that this permanent thermometer recorded, while the gases were still under pressure, temperatures from 50 degs. to 70 degs. Fahr. higher than the final temperatures at atmospheric pressure.

The clay cover not being obtainable in all cases, gave way to one made of 2-in. plank, chinked with cotton waste, and this has proved entirely satisfactory.

Previous methods of measuring the temperatures of the exhaust have in most cases furnished results which were surprisingly low; and not until Professor Robertson's paper on "An Efficiency Test of a 125-h.p. Gas Engine" (*Transactions*, Vol. XXI., A. S. M. E., p. 396) has the writer seen a series of temperatures for the exhaust which seemed reasonably accurate. Professor Robertson secured by means of a copper-ball calorimeter values above 1,000 degs. Fahr., and in one instance records 1,209 degs. Fahr., occasioning this remark by Professor Thurston: "The possibilities of still further thermodynamic gain are indicated by the temperature of the exhaust gases above 1,000 degs. Fahr., and far above that of the prime steam of our steam engines."

In Professor Robertson's second paper upon the same subject (*Transactions*, Vol. XXII., p. 612) he reports temperatures of the exhaust as found by a La Chatelier pyrometer, ranging from 1,410 degs. Fahr. to 1,805 degs. Fahr., and states: "These temperatures appear to be rather high—so high, in fact, that the author has examined other data at hand to see if any confirmation of the above figures could be found."

It is the opinion of the writer that the last figures quoted by Professor Robertson are not far from correct for the engine tested, but the pyrometer used is far too expensive and requires too much special apparatus, as well as special calibration, to make its use possible in most tests.

It takes but a moment's consideration of the problem to show that very little if any thermodynamic gain is possible by any attempted reduction of the temperatures of exhaust in the average gas-engine of good modern design, unless accompanied by a reduction of the terminal pressure as shown by the expansion curve.

With terminal pressures ranging near 50 lbs., it is quickly shown that the

exhaust temperatures must of necessity be much higher than generally recorded. Suppose, for example, that the expansion line of the card shown in Fig. 9 be continued to full cylinder volume, as shown by the point H, the pressure at H is found to be 50 lbs. absolute. Suppose the temperature of the mixture in the cylinder, composed of air and gas, taken in during the suction stroke, and mixed with the neutral gases filling the clearance space, to be only as high as that of the room, say 70 degs. Fahr., or 529 degs. absolute at the point A (Fig. 9), since the volume at H is the same as that at A, the absolute temperatures wlil be proportioned to the absolute pressures; or if—

T_a = absolute temperature at A = 529 degs.,
P_a = ,, pressure at A = 14·7 lbs.,
P_h = ,, ,, at H = 50 lbs.;
then T_h, the absolute temperature corresponding to the pressure at H, will be derived from $T_h = T_a \frac{P_h}{P_a}$; $T_h = 529 \frac{50}{14{\cdot}7} =$ 1,800 degs. absolute, or 1,341 degs. Fahr. with the temperature of the mixture taken at 70 degs. Fahr. only. Actually the temperature of the mixture is much higher than this, and by means of the new apparatus described in this paper this temperature is readily deduced. The temperature secured at atmospheric pressure by means of the exhaust receiver is the temperature of the neutral gases that fill the clearance space of the cylinder.

Some Notes on the Commercial Management of Electrical Tramways.

By T. W. SHEFFIELD, A.M.I.Mech.E., A.M.I.E.E.

(Continued from page 67.)

Signalling.

THE question of signalling on electrically-operated street tramways is apparently not advancing as it should do, yet there are many instances in some of our large cities where the adoption of such a system would minimise any chances of collision at certain junctions, more especially where sharp curves occur, or where street traffic is controlled by the police. It is hoped that our tramway managers will take the matter up seriously, and not wait to learn wisdom from disaster. By common consent the travelling public is the most valuable asset the tramways systems have, and if their safety necessitates the enforcement of rigorous Board of Trade rules when they travel on steam railways, it is obvious that the same protection should be afforded by the corporation or company controlling electrical tramways.

The signals should be electrically operated, and rendered visible at night by electric lamps. In conjunction with this, a small portable telephone set for each car, connected up so as to allow communication with the general manager's office, generating station, and car depôts, would be invaluable in cases of emergency.

Point Switching.

There are in existence two or three systems having for their object the instantaneous automatic adjustment of points on the rails and overhead wires, adjustment of which is effected by a small switch operated by the driver of the car. The switch is connected electrically with the trolley head, and is so arranged that when passing a convenient position in front of the points to be moved, by merely turning the switch the points on both trolley wire and rails are opened, while a second contact, after passing the points, closes them. The necessary battery for the circuits is enclosed in a box on the rim of the pavement, similar to those already in general use on electric tramway systems. These contrivances, which are extremely simple in mechanism, are also fitted with a hand lever, which, in case of any breakdown in the electrical equipment, can be operated to set the points and overhead wires by one movement.

At present this work is done by a man or a boy stationed at each junction, who first moves the points on the rail with an ordinary steel lever, and then hurries to the side of the road and pulls a wire which controls the points on the trolley wire.

Instructions for Motormen and Conductors.

Many motormen are anxious to learn the electrical principles underlying the operations which they daily perform. In order to foster this desire on their part, it would be highly advisable for managers to issue from time to time as the circumstances warrant concise instructions for the use of motormen and conductors, generally dealing with the special features of the system and the appliances under their control. In conjunction with this it would be advisable to issue weekly and daily "Report Cards," as shown on p. 131, the adoption of which would provide the means of checking all matters and expenses relating to each individual car. The idea would be for the men to hand their cards in as occasion required, the same being duly examined and passed by the car-shed inspector, and finally handed over to the manager for attention.

In order to induce them to take a keen interest in the economical control of a

car equipment and use a minimum amount of current, it might be advisable to adopt a bonus system for motormen, and divide a proportion of the nett saving according to the results achieved under the different conditions of the service. The current consumed on each car could be readily measured by means of a recording tramway watt-meter such as a Thomson-Houston instrument, which is designed and made for permanent installation in tramcars, and has proved satisfactory in cases where it has been adopted.

It may be interesting to note that many tramway managers agree that the average waste through carelessness of the motormen amounts to 20 per cent. or more of the total energy consumed. From tests recently made, as much as 25 to 30 per cent. difference has been found among motor-men running the same car under almost exactly similar conditions.

From the foregoing facts, tramway watt-meters installed with the system of a yearly bonus for motormen would enhance the profits by a saving in the amount paid for current, and by relieving considerably the wear and tear on the lines and wheels through needless braking.

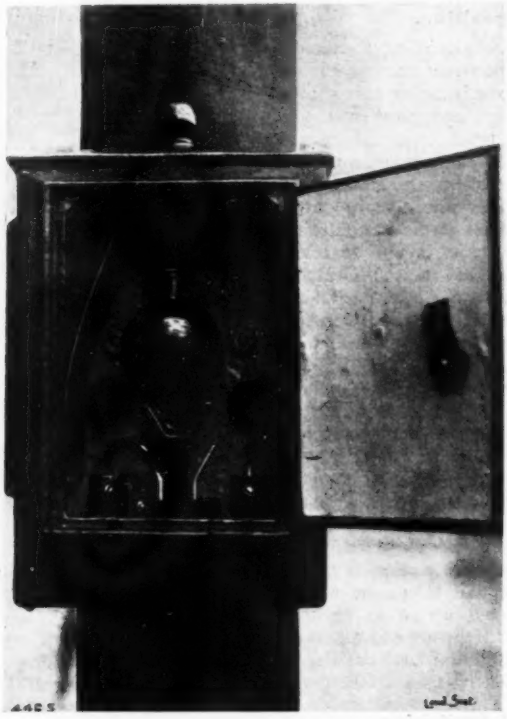


FIG. 1.—PATENT EARTHING DEVICE FOR SHORT-CIRCUITING THE WIRES IN CASE OF EMERGENCY.

A Few Points on Car Regulations.

1. All tramway handrails to be totally insulated, in order to prevent any shock to passengers.

2. Speed indicators should be adopted throughout the system, and coloured lamps to indicate high speed at night-time.

3. The driver should have an electric bell, operated by a small press-button on the brake-handle, instead of the prevailing foot-lever and gong.

4. Adjustable rotary brushes, fitting in the groove of the tram lines, should be used in front of each car-wheel, in order to keep rails clean, thus effecting better contact between line and wheels.

5. First-class certificates should only be issued to motormen conducting the service on difficult routes; second-class certificates for motormen on easy routes and outside districts.

6. A notice to warn passengers on leaving cars to always make for the pavement on the left-hand side, in order to avoid crossing the opposite tram lines.

7. The tops of cars to be protected with three insulated rollers, to allow any falling trolley-wire to run off clear of the car.

8. The buffer place to be on the buffer principle, and not fixed as at present.

9. The trolley-head of the car should not be reversed until the passengers have alighted at the terminus; this dangerous practice leaves the passengers in the dark as they are descending from the top of the car.

10. Signal communications at all crossings and points to be electrically operated.

11. A complete code of signalling between conductor and driver.

12. Separate instruction books to be kept on each car in special places provided.

13. Tops of cars to be provided with suitable arrangement for covering them in wet weather.

14. Suitable ticket-holders to facilitate easy handiing when collecting fares.

In connection with Point No. 7 it may be interesting to allude to Messrs. Donaldson & Hollingworth's patent earthing device, for short-circuiting the wires in case of emergency.

As will be seen from Fig. 1, the device consists of a gravity switch enclosed in a cast-iron box, which is fixed to one of the street standards, or to any other suitable support. One terminal of the switch is connected to the live or trolley wire and the other terminal is connected to the rail or earth. The contact maker is held above and clear of the terminals by a cord, the other end of the cord being fastened to a sheet of glass, which forms a panel in the side of the box.

In case of danger due to broken trolley wires, or broken telephone or telegraph wires falling across the live wires, the glass is to be broken; this immediately releases the contact maker, which falls, and short circuits the live terminal and earth terminal, bringing out the circuit breaker at the power station and making dead the wires on the particular section where the accident has occurred. While the contact maker is down it is impossible to make the line alive. As soon as the danger is cleared it is only a question of a few minutes to replace the details of the switch.

CITY OF DURBAN TRAMWAY DEPT.

Daily Report. No. _____

To Mr. _____ 19 .

Car. No. ____ Route _____

Motors _____

Controllers _____

Brakes _____

Lifeguards _____

Trolley Head _____

Lamps on Circuit _____

Number of Journeys _____

Renewals _____

Remarks _____

Driver _____ Conductor _____

Signed _____

As affecting Point No. 13, Figs. 2–4, show the covering for the upper decks of tramcars designed by Mr. C. R. Bellamy, manager of the Liverpool Corporation Tramways.

Mr. Bellamy has found from experience that his first idea of covering the whole of

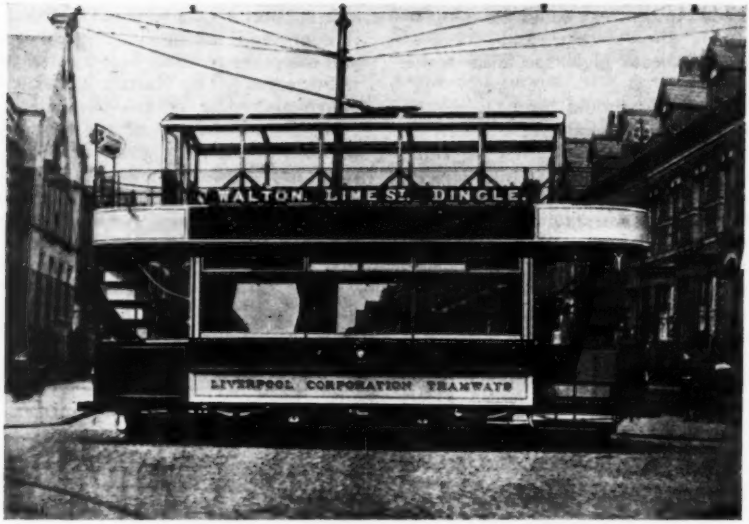


FIG. 2.—CAR IN USE ON LIVERPOOL TRAMWAYS WITH COVERING FOR UPPER DECK; CURTAINS NOT DRAWN.

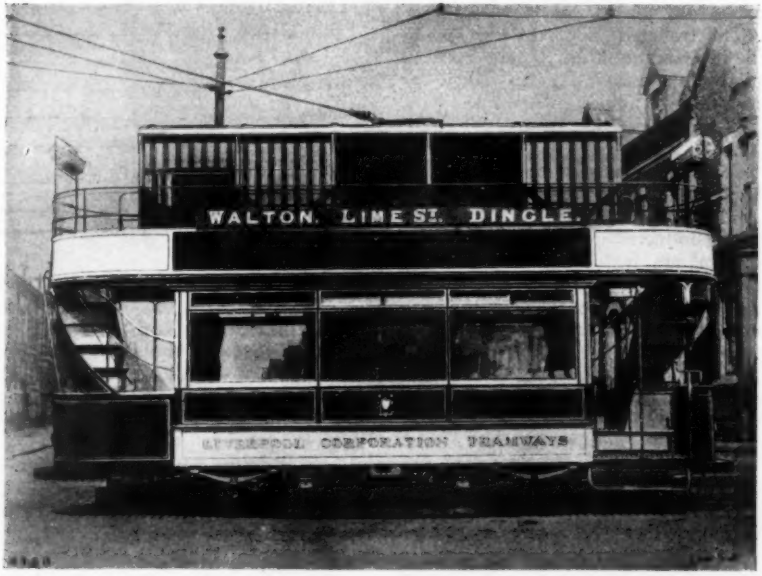


FIG. 3.—CAR IN USE ON LIVERPOOL TRAMWAYS: WATERPROOF CURTAINS DRAWN.

the top of the car was not satisfactory, and in order to avoid the uprush of cold air he has set the covering back clear of the staircase, which also dispenses with any appearance of topheaviness which the entire covering would give to the car. Only one-third of the total roof covering is permanent. This has been found sufficient to carry the trolley-pole base, and at the same time preserves, as far as possible, the open character of the upper deck. The roof of the cover is 6 ft. 2 ins. in height from the deck of the car, the frame consisting principally of steel work. Two-thirds of the roof and the sides are enclosed at will by means of waterproofed curtains on the American principle, which can be operated by a passenger simply and speedily, so as to effect the entire covering of the upper deck within half-a-minute of requirement arising. The ends are protected by glazed screens fitted with doors. By abolishing the trolley standard on the upper deck and projecting seats over the stairway, additional accommodation has been provided for ten passengers with a clear passage up the centre. The total additional weight is under half a ton.

In Liverpool, during the winter months, the tramway traffic declines considerably, and it is necessary to maintain during inclement weather practically a maximum car service for the purpose of providing sufficient inside accommodation. By the design of the car covering in question, Mr. Bellamy has overcome the difficulty by providing a top cover for tramcars which shall not destroy the amenities of outside travelling in fine weather, while rapidly and effectively providing adequate shelter and protection during inclement weather. This covering will also, to a considerable extent, solve the very vexed question of overcrowding, as passengers will not be allowed to stand until the whole of the seating accommodation is occupied.

Mr. Bellamy intends fitting forty-two cars in the first instance with this type of cover, so that the system may have a sufficiently extensive trial during this winter to enable his committee to determine whether the whole of the cars should be similarly fitted.

FIG. 4.—END VIEW OF COVERED CAR: LIVERPOOL TRAMWAYS.

The appliance is not patented, and therefore is open to all the world. Our illustrations show the covering and its construction very clearly, and, no doubt, ere long we shall see this principle

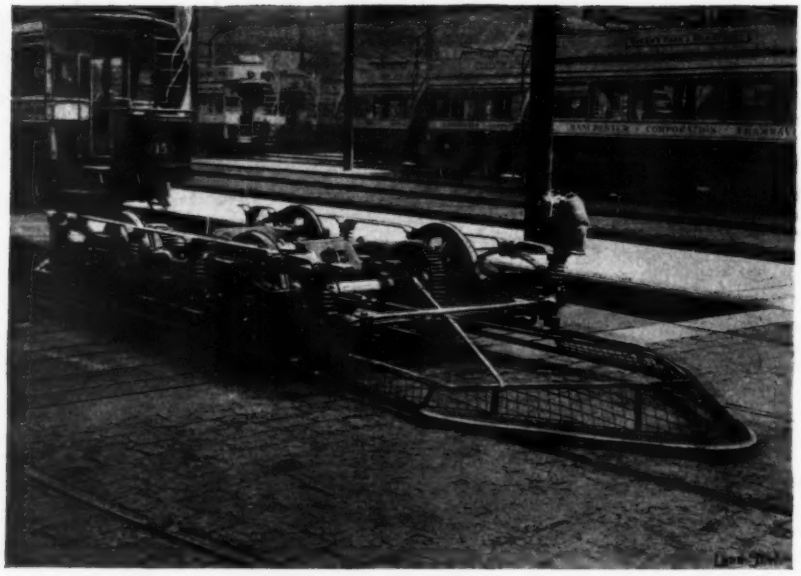


FIG. 5.—MANCHESTER TRAMWAYS: TYPE OF LIFEGUARD PROPOSED FOR ADOPTION.

applied on many of the tramcars in this country.

Lifeguards on Electric Cars.

One of the most interesting problems in a successfully worked tramway system is the question of lifeguards. In touching upon this all-important matter it may be pointed out that a great deal of misapprehension exists in the public mind as to the protective requirements for safeguarding street traffic in connection with electric tramcars. The introduction of street electric tramways attracted close attention, and accidents which would have escaped notice under the old horse traction obtained considerable prominence, resulting in a general belief that the new system of electric cars has led to a large increase in the number of street accidents. This exaggerated scare at one time in the history of street electric traction threatened to prejudice the interests of electric tramways considerably—if we are to take as an example some of the absurd letters written in the Liverpool daily papers, which pointed out at the time how the public mind was unnerved at the accidents which occurred in the early stages of Liverpool's electric tramways. Notwithstanding these difficulties, the experience in Manchester and Liverpool affords fair evidence that there is less risk of fatal accidents under electrical traction than under horse traction, as the following figures, taken from the report of the Liverpool Corporation, point out. Taking the figures for the last three-and-a-half years, comprising the period of the Corporation control, for the purpose of establishing a comparison between horse and electric traction, it is found that in 1898, which may be regarded as the last year of horse traction, the fatalities amounted to one in 6,000,000; in 1899, with mixed traction, one in 8,000,000; in 1900, one in 7,500,000; and for the first half of the present year, one in 9,000,000. The total fatalities in relation to passengers were as follows :—

Year.	Fatalities.	Passengers.
1898	7 ...	41,772,034
1899	8 ...	63,771,450
1900	11 ...	82,367,958
1901 (half-year) ...	5 ...	47,776,411

Of the total cases 17 were in connection with electric cars, of which three occurred to passengers attempting to *board* or *leave the cars while in motion*; seven to collision and miscellaneous causes, and only seven were killed under the cars.

A person knocked down by an electric car is generally thrown clear of it, as proved by the figures that, while in 1900 121 persons were knocked down by electric cars, 10 only got underneath them (eight of that number being saved by the guards and two killed). The lifeguards, therefore, were effective in 80 per cent. of the cases in which they were required, while they were not required at all in 91 per cent. of the total cases. From the above facts one concludes that the type of lifeguards in use have been fairly effective.

The type proposed for use on one of the leading tramway systems is illustrated in the sketch, Fig. 5. The main feature of this lifeguard is its attachment to the axle-box, which prevents the see-saw action that renders some of the existing guards inoperative. Another important feature is, that the guard is fixed and has no working parts to get out of order.

The question of lifeguards is one of vital importance to the community generally, and all care should be taken and experiments carried out to procure the best lifeguards to meet the conditions of the existing tramways. The first cost should be a secondary consideration, as a reliable and effective guard would minimise any costly claims against the tramways departments.

Brakes.

Although we can gather from the foregoing remarks that the risk of life is not as great as is generally imagined, notwithstanding this, it is a regretable fact that accidents on electrical tramway systems are becoming far too numerous, both from the point of

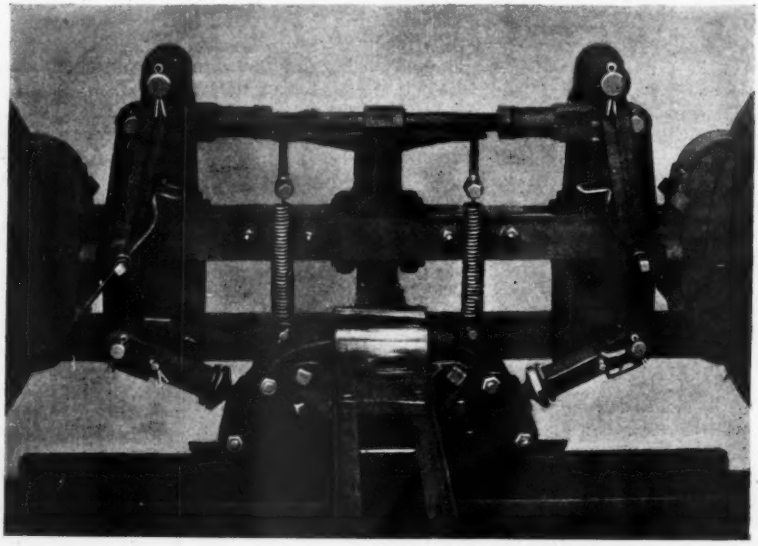


FIG. 6.—COMBINED TRACK AND WHEEL BRAKE IN USE ON SEVERAL TRAMWAY SYSTEMS

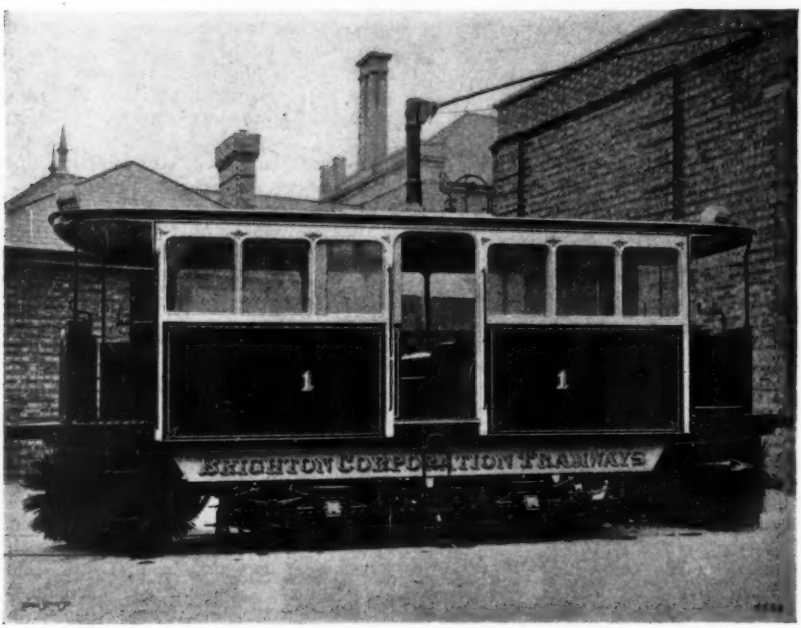


FIG. 7.—COMBINED SNOW SWEEPER, RAIL CLEANER AND TRACK WATERER IN USE ON THE BRIGHTON CORPORATION TRAMWAYS.

view of the public, and for the reputation of tramway systems. It lies with the managers to minimise such disastrous issues by allowing no consideration of time or expense to interfere with the adoption of the best brake obtainable to control the car under all conditions, seeing that safety is the first vital consideration due to the travelling public.

There are several brakes in use, and strong claims are made for most of them; some of them are simple in construction and application, whilst others are more complicated, and on this account are to be avoided.

Fig. 6 shows a type recently brought out, which has a powerful braking effect on the car in three different operations. It is at one and the same time a track-brake, a wheel-brake, and an axle-brake. The main feature of this brake consists of a horseshoe electric magnet suspended by springs from the truck frame, the pole pieces hanging down immediately over the broad surface of the track rail. The poles are fitted with detachable brake shoes, the operation of braking taking place when the magnet is excited and drawn down on the track rails, with the effect of an ordinary track-brake, and with the advantage that the grip of the shoes and the rails does not in any way reduce the grip of the car-wheels on the track, thus the effective weight of the car is in no way diminished. This brake has been adopted on several tramway systems in this country, with results that have justified the claims of its promoters.

Another brake of a satisfactory character is operated by air. Its main feature lies in the fact that it is capable of instant application on the steepest gradients, or, in cases of emergency, in a crowded street. It should be borne in mind that it is quite as imperative to have an effective break on the level for

street traffic as on any gradient. The brake in question is capable of bringing any electric car to a standstill in less than its own length, running at its normal speed. Although the breaking action is practically instantaneous, the shock experienced is extremely slight, owing to the air cushion taking up a considerable portion of the shock, thus minimising any wear and tear of the car. This demonstrates very forcibly that an emergency brake acting on the track itself is the only proper one for tramway work, and it will no doubt be very extensively used, especially if the good results achieved by corporations who have adopted this system are inquired into by parties interested in this important question.

Track Cleaning.

The importance of maintaining the track and rails in a clean condition has been mentioned above. As early as 1900, Messrs. Brecknell, Munro and Rogers, of Bristol, introduced in that city a machine of special construction for watering and sweeping the track, which was probably the first machine of its kind built in this country. It has proved very successful, and eminently suited to the system upon which it is working.

The water-tanks, which are in two sections, have each a capacity of 750 gals., the space between them on the deck being utilised for the motors and the gear for driving the brushes. The latter are of a very substantial construction, composed of rattan cane, and driven by roller-chains and machine-cut chain wheels. It may be noted that this gear runs practically silently, and seems to give many advantages over bevelled wheels and shafting drives.

The brushes are of such a width as to cover the whole of the track and a small portion of the road outside the rails, and the diameter admits of a very large amount of wear. The total weight

FIG. 8.—MESSRS. G. F. MILNE'S LATEST TYPE OF CAR.

of this machine, loaded ready for the road, is about 10 tons. The truck was of special design, having a cantilever projection to pick up the over-hang on the off-side of brush. In later machines this practice has been abandoned, and a standard truck of either of the well-known makers is universally adopted. The amount of water carried is found sufficient to water a single track of 10 miles with two $\frac{3}{16}$-in. nozzles on each side.

The machine shown in Fig. 7 is of later design, and embodies the most recent practice. It has all the principal features of the machine above described; but the adoption of a standard truck alters the general appearance of the machine, bringing the platform somewhat lower and the general outline more in conformity with the appearance of an ordinary passenger car, the great advantage of this being that spare truck parts, etc., can be used for either, indifferently.

This sweeper has some special track cleaners, which the builders of these machines are now fitting to all their sweepers; they have compensating movements which permit of the cleaning of the rail on any curve, and any serious obstruction is easily negotiated. Also, in the event of the cleaner being thrown out of the rail, it is automatically replaced without any attention from the crew. The scraper cleans the groove and scrapes the tread of the rail, depositing the refuse a few inches outside the track.

Tramways versus Railways.

The rapid development of electric traction is causing the railway companies to give better attention to their suburban traffic than hitherto, but in many cases the awakening has come late, and the tramway systems are reaping the advantages due to the apathy of their rivals. How much more so will this be when the up-to-date management caters for the middle-class citizen, as is done in cities such as Philadelphia, Chicago, and other large cities in the States? If Manchester, for instance, were in the States, it would have intercommunication with all the important towns in Cheshire, Derbyshire, Staffordshire, and Yorkshire, and specially furnished cars would be ready at a few hours' notice to take a party to any point of the system, with the advantage of the car stopping at any point required. What a field this opens out for citizens who, after a busy week in our crowded cities, desire a quiet run into the country district near at home, without the inconvenience of the usual railway station, with its excitement, noise, and dirt, which detracts so much from the change!

But electric cars have been established for far more important functions than for mere excursions. They are the main and foremost means of the solution of the housing question. By the aid of tramways the worker will be enabled to reside a few miles away from his work, and, in many cases, its unhealthy neighbourhood. For this purpose, every endeavour must be made to keep the tram fares low, and the tram service early, speedy, and punctual. Workmen's cars can easily be maintained on account of less traffic in the street in the early part of the day. In this connection there promises to crop up at an early date the great questions of halfpenny stages, contract tickets, special cars, and return tickets; this will also bring up the vital question of running special cars and services for those who do not require to get to business so early. Also the question of running direct cars, intermediate cars, and special cars, etc., to meet the demand of the passengers who live in the vicinity of the half-way stage.

Railway companies still have the monopoly over the long routes, but they will not have this monopoly as hitherto over the suburban traffic, for the very obvious reason that the speed on electric cars is quite as high as on a suburban train running on a line choked with traffic, with the advantage that it is possible to get to the centre of the city without changing. Taking into consideration that what applies to the passenger car applies to the goods traffic as well, it is very apparent that railway companies will have to redouble their energies if they are to effectually compete with the tramway, and to seriously consider the advisability of adopting electric traction for their suburban traffic.

T. W. Sheffield.

Nile Irrigation Works.

By W. NOBLE TWELVETREES, M.I.Mech.E.

(Continued from page 58.)

I.—The Delta. *(Continued.)*

A NAVIGATION lock is provided at one end of the weir across each branch of the Nile, the foundations being formed in the manner already outlined. During construction the core walls progressed simultaneously with the side walls of the lock foundations, and as soon as the sluice passages in the lock chamber walls were completed, the discharge of water then passing between the advancing ends of the core walls was diverted through the locks so that the core walls could be closed right across. Channels were left in the core walls, in order to avoid getting a head of water on the walls before the clay and rubble pitching were in place on both sides. Channels were also left in the footing and cross walls until the last, to prevent a head coming on any of the walls until all essential work was complete. In some places cracks appeared between the blocks of grouted masonry, owing to settlement of the last-made block before the next one could be completed. At first the practice in such a case was to "jump" a bore hole along the line of the crack down to below the level of the clay filling, and after the clay and rubble pitching were in position, to pour in cement grout to fill up the crack. Afterwards it was arranged to leave vertical holes above the junction lines of the blocks, whether cracks appeared or not, and these holes were afterwards grouted up with cement. This plan saved a good deal of time, as the labour of boring holes very much exceeded that necessary for the formation of holes as the work progressed. A grouting hole of this kind was formed by fixing a semi-circular pole in the centre of the outer end of each timber caisson. When the block had been made, the pole was withdrawn, and in its place a tapered rod, wound entirely with rope, was fitted so that the making of the next block would complete the envelopment of the rod and rope. As soon as the block had set, the rod was extracted and the rope could then be pulled out, leaving a clean hole from top to bottom at the junction of the two blocks. Another method adopted was to fit a plank across the semi-circular hole first made, and then to fill the latter with sand, so as to keep out the grout used for cementing the blocks while the next block, with a corresponding semi-circular hole, was being finished. The sand was afterwards removed when the time came for grouting up the hole.

During the construction of the Damietta weir, strong springs were noticed just above the footing wall, after water had been directed through the lock channel. These springs were due to the outflow of water, held between the core, footing, and cross walls. In three of the compartments the water level fell to that of the river downstream of the footing wall, but the other two compartments held water. As the footing wall became quite watertight after the first flood, and as it was known that the downstream bed of the river would be little if at all lower than the top of the wall, it was not thought necessary to make any alteration to the Damietta weir. In the Rosetta branch the minimum downstream water level falls somewhat lower, and the cross-section of the weir was modified. The footing wall was carried down about 20 ins. lower, and additional clay was placed on the upstream side. As a precaution against leakage in spite of these modifications, a filter bed was added downstream to prevent the removal of material. Both weirs were practically finished by the end of

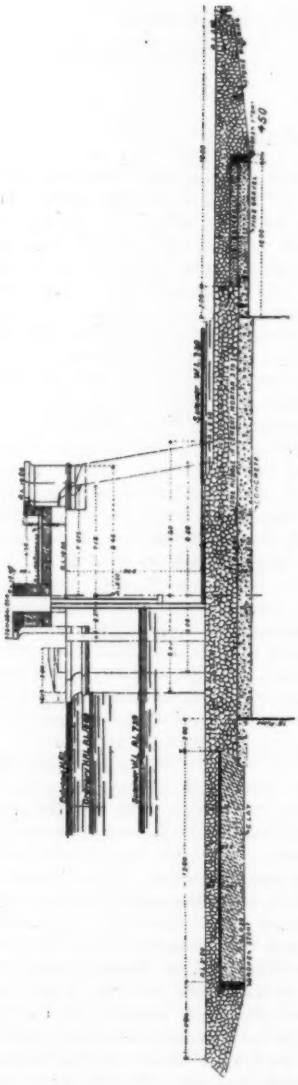


FIG. 8.—THE ZIFTA BARRAGE. SECTION OF FLOOR AND SUPERSTRUCTURE.

July, 1900, and by the middle of May, 1901, their crests were raised to the full height, and finished with ashlar slabs. The following table gives the quantities of work executed during the four seasons of construction.

DESCRIPTION.	CUBIC YARDS.
Dredging	531,736
Earthwork	355,608
Grouted Masonry	58,093
Skipped Concrete	2,213
Rubble Masonry	21,577
Brick Masonry	13,395
Ashlar	3,549
Dry Rubble	227,888
Heavy Talus Blocks	36,273
Clay on Sides of Walls... ...	73,441

In addition to the construction of the weirs, which are capable of holding up about 10 ft. of water, the height of the upper gates of the Delta barrage was increased by nearly 5 ft., and an extra winch was furnished for working the gates of each portion. Thus in 1900 it became possible to hold up 18 ft. of water above the barrage, or 3 ft. more than had ever been previously contemplated.

The total cost of these works, estimated at £E530,000, was actually only £E434,000* and the saving would have been greater had it not been for the abnormally high price of cement.

In 1901, the new weirs made it possible for the whole summer supply of the Nile to be completely utilised without subjecting the Delta barrage to a greater head than 4·5 ft., and on the approach of the annual flood to raise the level upstream of the barrage to R.L. 15·50 (*i.e.* 15·50 metres above mean sea level) by July 23, before any water was allowed to pass, and without subjecting that structure to more than 9·84 ft. head. A most important result was the economy effected in dredging the Ismailiyeh, Menûfiyeh, and Behêreh canals, and a still more important result was that the new weirs practically saved the cotton crop, thereby justifying their construction in the very first year of their existence.

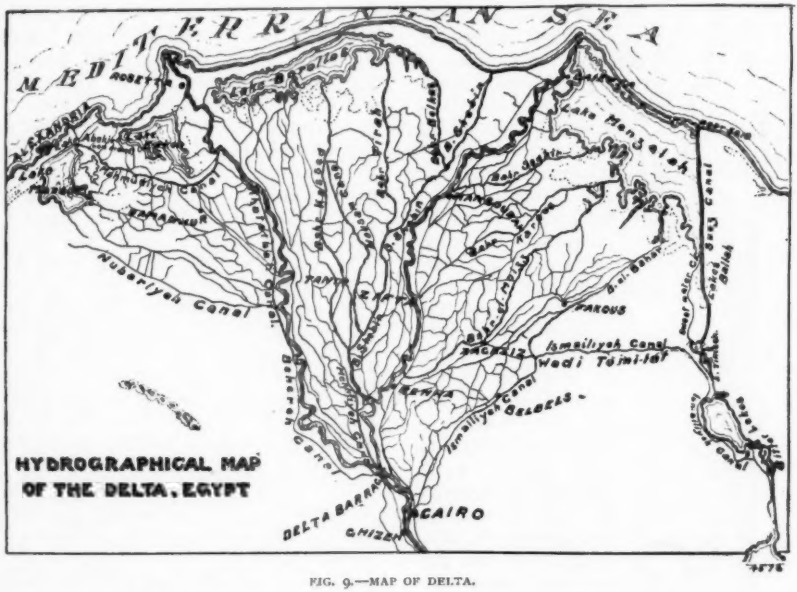
Formerly it was unsafe to raise the level upstream of the Delta barrage above a certain limited height until sufficient water had

* NOTE.—The value of an Egyptian pound (£E) is £1 0s. 6*d*. sterling.

passed down each branch of the river to raise the downstream levels, so that the head on the structure should not exceed safe limits. Consequently the first rise of the flood in every year was practically wasted for irrigation purposes. Now, until the up-stream level of 15·50 metres above sea level is reached, no water is allowed to pass down either branch of the river, and every drop brought down by the first rise is passed into the irrigation canals. When the level of 15·50 metres is once reached, it is maintained. The extreme value of these facilities to the whole of the Delta should be sufficiently obvious.

One of the most important undertakings in hand during the year 1901 was the Zifta barrage, on the Damietta branch of the Nile, a work which was commenced before the completion of the weirs below the Delta barrage. A barrage on the Damietta branch between Zifta and Samanud was suggested several years ago, and a design for it was prepared by the present Sir W. Willcocks long before the weirs were seriously contemplated. To some extent the facilities afforded by the new weirs had lessened the need for an additional barrage on the Damietta channel, yet not sufficiently to justify the abandonment of the scheme. In his last Report to the Under-Secretary of State, Sir R. Hanbury Brown says:—

"In spite of the power the weirs give us of raising the water service above the Delta barrage to the level that gives nearly maximum discharges at the canal heads, taking off above it as early as the first week in July, the demand for water is everywhere so great that rotations cannot be taken off until after 15th August."


MEDITERRANEAN SEA
Rosetta
Lake Mareotis
Lake Maadiyeh
Lake Mariout
Nubariyah Canal
Ismailiyah Canal
Wadi Tumilat
Bahr Hadus
Bahr Shibin
Bahr Sherkawi
Bahr Sherbini
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summer time the Damietta branch of the Nile will probably be employed as a main irrigation canal, and the Zifta barrage will serve to store up water for distribution. It will therefore be seen that the main function of the new barrage will be to hold back water for the northern Delta canals, which will then have a direct and independent supply of their own. A cross-section of the Zifta barrage is given in Fig. 8, by which it will be seen that four metres (13·12 ft.) of water is intended to be held up. There are 50 openings, each 16·4 ft. wide, and abutment piers between each group of 10 openings. Cast-iron grooved and tongued sheet piling with cemented joints is provided upstream and downstream for the protection of the platform, the piles along the upstream face being 16ft. long, and those on the downstream side 10 ft. long. A lock is provided at the western end of the structure, with a chamber 39·36 ft. wide by 213·2 ft. long, and a lift-bridge will afford facilities for road traffic. Little more than preparatory work was undertaken during the first season, an effort being made to get down the lock foundations and part of the regulator floor, so that these portions of the work might be used during the second season for the passage of water whilst the remainder of the foundations were being formed. The first pile was driven on May 5, 1901, concreting in the lock floor was commenced on May 19, and by the end of July the lock foundations and sills up to 16·4 ft. above the foundation bed had been built, in addition to about 233 ft. of the regulator floor, 9·84 ft. thick, with pier bases on this length up to 5·3 ft. above floor level. The purchase of engineering appliances for the construction of this barrage was discouraged, in view of the fact that the extensive plant then in use at Asyût, and belonging to the Government, would be available in the year 1902. This was a somewhat serious handicap, but fortunately it was possible to utilise some of the plant procured for the Delta barrage. The Delta Light Railway proved to be extremely useful for the transport of materials, and a siding was laid down by the State Railway from Zifta to the site, so that cement, piles, and other goods could be delivered direct upon the works. Before the close of the year 1901, the second season's work was begun. The bottom grooves of some piers were fixed, and the piers were built up to the level of the grooves, so that the bays between should be ready to pass the river discharge, whilst the remainder of the foundation area was enclosed by "sadds," and pumped dry for the continuation of work. It is hoped that the Zifta barrage will be in complete working order by the summer of 1903.

FIG. 10.—SECTION OF MENOUFIYEH CANAL (DISCHARGING 10,846 CUB. FT. OF WATER PER SECOND IN FLOOD TIME).

The three structures which have been mentioned, the Delta barrage, the Weirs, and the Zifta barrage, represent but a small proportion of the work commenced by Sir Colin Scott-Moncrieff and continued under the direction of the present able chief of the Public Works Department. Before the British occupation, the Administration consisted of men, of whom it has been said that they lacked courage to face the situation, and whose one idea of duty was the shirking of it. They did not favour the repair of the Delta barrage, for they feared the cost, and saw that if the water level of the Nile were raised alterations would be rendered necessary to the whole canal and drainage systems of the Delta. Therefore, pumping stations were proposed for delivering water at the required

level, and the tremendous accumulations of silt in the canals, amounting to many millions of cub. yds. per annum, continued to be dug out by the forced labour of an army of men, numbering from 100,000 to 150,000. Fortunately for Egypt, the advent of Sir Colin Scott-Moncrieff was speedily followed by the formulation of a general scheme, which, so far as concerned the Delta, was designed for the attainment of the objects stated below:—(1) the supply of the maximum possible quantity of water in both the deep and the shallow canals; (2) the maintenance of a higher level in the canals so as to reduce pumping to a minimum; (3) the re-organisation of the canals so as to reduce the deposition of silt and the necessity for forced labour; and (4) the re-organisation and extension of the drainage system.

It would be impossible, in an article such as the present, to convey an adequate idea of the system of waterways which cover the surface of Lower Egypt, the more important of which may be seen in Fig. 9, which is a hydrographical map of the Delta. Briefly, it may be said that there are six main irrigation canals taking off above the Delta barrage. These are veritable rivers, the largest being the Menûfiyeh canal (Fig. 10), which even in June discharges a volume of water greater by one-fourth than that carried by the Thames in mean flood. At the time of the British occupation the canals were badly designed, escapes were lamentably deficient, and the whole scheme of irrigation was a standing proof of past incapacity and neglect. Fig. 11 shows a system of canals, the Nagar, the Sabbal, and Neniah, from which, in 1884, 1,181,718 cub. yds. of slime were removed. After remodelling, the quantity fell to 138,070 cub. yds. in 1886, and about 39,000 cub. yds. in 1887. The single lines in the figure indicate new canals now used for all flood irrigation. Two new escapes, marked *A* and *B*, provide for the discharge of surplus water into the river. Fig. 12 shows, among others, three canals, the Sâhel, Khadarawiah, and Ataf, originally fed from the Nile. These canals suffered much from silt deposits, which were entirely obviated by the construction

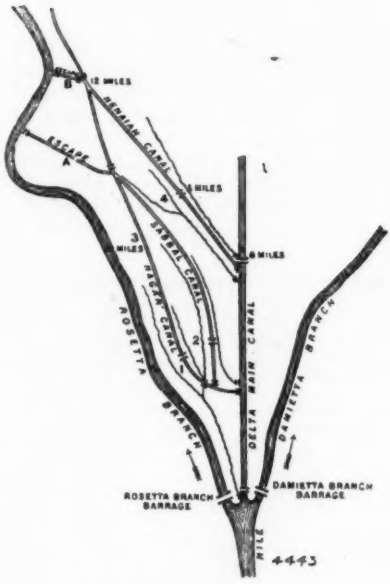

FIG. 11.—TYPICAL IRRIGATION CANALS (ROSETTA BRANCH).

FIG. 12.—TYPICAL IRRIGATION CANALS (DAMIETTA BRANCH).

of the new summer canal marked *A B C* on the plan.

Since the year 1885 a sum of over £E1,500,000 has been expended upon drainage works in Egypt, and the total length of new and remodelled channels now amounts to over 2,600 miles, the greater portion being in the Delta. New irrigation canals have also been made, the work of reclamation has been vigorously taken in hand, and many important structures besides those already mentioned have been carried out.

FIG. 13.—MAP OF NILE VALLEY.

The following are some of the more important works undertaken during the years 1900-1. In the former year the Saidiyeh canal head was replaced by a new one of sufficient size to provide for modern requirements. The Sâhel-Markaz canal widening was started; new feeder heads were provided at Gamazah and Tourah; the Ghizeh canal was enlarged and lengthened, so as to pass through iron pipe siphons under the old Abu-Agooz escape and the Zummur canal. The old Abu-Agooz escape, useless for this purpose, has been made to serve as a head for the Ghizeh canal. Two important regulators, one at Behreshen and one at Zummur, have been constructed, as well as seven smaller regulators and seventy pipe outlets. Two old regulators were remodelled, and a new channel was dug to connect the Agooz head with the Ghizeh canal at Kafr Amr.

The more important works of the same class undertaken and continued in the Delta during 1901 were as follows:—In the provinces of Sharkiyeh and Dakhâliyeh remodelling was continued in the Bahr El-Bagar, El-Arin, Saft, Hadus, and Siru systems, and many branch drains were perfected, these works involving the construction of many masonry and timber structures, in the shape of bridges, siphons, and aqueducts. In the province of Gharbiyeh extensive improvements were undertaken, in the Bahr Shibin, Sharkawiyeh, Bahr Mallah, Ariamum, and Nashart systems—all of very considerable area, and each comprising a large number of branch drains. In the province of Behêreh drains in the Edku and Mareotis systems were proceeded with. A new regulator and lock for the Ismailiyeh canal was under construction in 1901, to replace a work which failed many years ago, owing to badly-designed foundations. In consequence of the difficulties connected with the soil, bricked well-foundations were decided upon. During 1901 the whole of these were sunk to the required depth. The canal in question is more than double the size of the Thames; and as the new head will be close to the river the deposi-

tion of silt will be prevented, and water will be economised. In addition to the head-works, some extensions were commenced in connection with the Siriakos and Bilbeis regulators on the same canal. The remodelling of the Dimereh regulator and the building of a new lock were commenced. The old head of the Behêreh canal at the Delta barrage having proved insufficient, it was decided to enlarge it. This involved the construction of two new spans and an entirely new lock, as well as the provision of new gates, similar to those at the barrage, for the whole structure. On the same canal a fine new regulator was commenced at Nikla. This work includes a barrage of five openings, each 26·24 ft. wide, and a lock 114·8 ft. long by 26·24 ft. wide, the object being to give control over the water at the time of discharging the Nikla basin. Up to the present the discharge has taken place into and across the Behêreh canal, a method involving considerable difficulty and danger. The new works were practically finished during 1901, only the lock gates remaining to be hung in 1902. A head was completed in 1901, at a cost of £E15,699 for the flood-feeder channel, proceeding from the Rosetta branch of the Nile to the Behêreh canal, the intake of which above the Delta barrage is closed after the flood has reached a certain height. The new head to the alternative channel is of much importance, and previous to its construction the feeder channel was closed by an earthen dam, or "sadd," which was annually cut on the arrival of the flood-water. It should be remarked, in connection with the main drainage of Lower Egypt, that a few years more, at the present rate of expenditure, will see the completion of the main drainage system for the existing cultivated area; although with an increased water supply new tracts of land will doubtless be brought into cultivation, for which further irrigation facilities will have to be provided. These remarks naturally lead up to the reclamation of land in the Delta, but space forbids more than an incidental mention of this important question. Something has already been done towards the recovery of those low-lying

FIG. 14.—BAHR YUSÛF, MINIA PROVINCE. SOME OF THE NEW WEST BASINS.

areas near the sea-board. Some of these were lost to cultivation in past years by the entire absence of drainage, others through badly-designed drains, and others again by neglect of ancient dykes, thus permitting the sea to enter, and to form salt plains and swampy lakes. For the reclamation of land that is impoverished, swampy, or entirely covered with water, drainage is a primary essential. Means must be provided for getting rid of water

FIG. 15.—PLAN AND ELEVATION, ASYÛT BARRAGE. (VERTICAL SCALE 4 TIMES THAT OF HORIZONTAL SCALE.)

of the wrong kind, and then the silt-laden flood of the Nile, which is water of the right kind, must be poured out in abundance to form once more a fertile surface for cultivation. Until the water supplies of Egypt are amply assured, complete restoration of her ancient prosperity is impossible. In the meantime something is being done. The drainage of Lake Menzaleh is in hand. Lake Mareotis, receiving the contents of the drainage channels of Western Behêreh, is prevented by the Mex pumping station from extending its borders; and the Wadi Tumilat, a depression between the Ismailiyeh canal and the desert, is in course of reclamation.

The drainage of Lake Abukir in 1887 constituted a striking example of the advantages possessed by modern engineering plant. The lake at that time covered an area of 31,000 acres, and it was entirely cleared of water by two 48-in. centrifugal pumps in 456 hours, running with a consumption of only 135 tons of coal. It was subsequently decided that the pumping plant should be removed to Mex, where, in addition to keeping Lake Abukir free from water, it would help in the reclamation of Lake Mareotis. The pumping station at Mex is the most important establishment of the kind in Lower Egypt; and the plant includes five Farcot direct-acting centrifugal pumps, in addition to those removed from Lake Abukir, the normal duty of the pumps being over 660 million gallons in twenty-four hours. In the winter of 1900-1 the pumps were actually obliged to work at full power for thirty-seven days; and in one day nearly 750 million gallons were lifted, while the quantity for the whole season was nearly 70,000 million gallons. In spite of all efforts, the water-level of the lake could not be kept down, and additional pumps are urgently required, so that the plant may be able to discharge more water into the sea than

can be brought down by the drains. The importance of such extension will be more fully realised when it is stated that the only outlet for the drain-water of Behêreh is the suction-pipe at Mex, and that the continuation of improvements in the province depends absolutely upon the pumping station. The pumping station at Wadi Tumulat is also employed in connection with drainage; and although it is on a smaller scale, the quantity pumped during 1901 approached 18,000 million gallons. Satisfactory progress is reported as to the reclamation works in this place, the main items of expenditure, besides pumping, being for the enlargement of the main drain, the suppression of about ten miles of the old Wadi canal, and the replacement of irrigation therefrom by new channels fed from the Ismailiyeh canal. The third pumping station in the Delta, at Atfeh, is used for lifting water into the Mahmûdiyeh canal, supplying the network of irrigation channels that water a large area in the province of Behêreh. This pumping station was rearranged some years ago by Nubar Bey, who discarded centrifugal pumps, and installed six water-wheels with scoops, working at low velocity. At the present time seven out of fourteen boilers at the station require replacement, and considerable expenditure is necessary in other directions. In spite of the obsolete nature of the plant the volume of water lifted in 36 days, during the season 1900-1, amounted to nearly 9,000 million gallons, equal to about 250 million gallons in 24 hours; and the level maintained at the tail of the Mahmûdiyeh canal was 80 per cent. higher than the normal gauge for that season—a matter of considerable importance to cultivators and to the city of Alexandria.

A further point, worthy of remark, in connection with the utilisation of the Nile is that each branch is closed near the sea by a temporary earthen dam, or sadd, during the summer time. The sadds serve to prevent the admission of salt water when the river is low, and they also raise the water level so that water flows by gravitation into the northern supply canals.

It would not be right to close the present part of our subject without emphasising the immense value to Egypt of the Delta barrage and its auxiliary weirs. As already mentioned, their utility was amply proved during the season 1900, which was in many respects one of the poorest on record. It is evident then that favourable results could scarcely be expected by agriculturists, and, in fact, there was widespread alarm when data were afforded for estimating the Nile flood. The conditions of water supply were such as in former times would have spread famine and desolation throughout the land. What actually happened in 1900 was that a cotton crop only surpassed in quantity on three occasions was secured to the people of Egypt. It is now universally recognised that this happy result was directly due to the completion of the Delta barrage works, aided by the admirable measures adopted by the Irrigation Department for the economical distribution of a scanty supply of water. The year following was also "very poor," yet it is recorded that while in 1900 public opinion was much perturbed by the low condition of the river, no alarm was manifested in 1901, and it is justly claimed on behalf of the Irrigation Service that the absence of all panic was due to the knowledge that a very large crop of cotton had been saved in 1900, in spite of the abnormally low water levels.

While the greatest work accomplished in Egypt as a result of the British occupation has been the creation of a capable and energetic administration, the completed Delta barrage must clearly be recognised as the most important of all the Nile irrigation works, for upon it absolutely depends the prosperity of the Delta, the most fertile region of the whole country.

II.—Upper Egypt.

That part of Egypt with which we are next concerned is limited to the cultivable land contained in the valley of the Nile, and in the fertile province of the Fayum, situated in a depression of the desert about 70 miles above Cairo. All the rest of the land is arid desert, for which there is practically no hope of redemption.

From Cairo in the north to the boundary of Egypt proper, near Aswân, in the south, the length of the Nile valley is about 600 miles, and, as will be seen by Fig. 13, it is bordered by hills which in some places approach close to the river and in others recede to a distance rarely exceeding 8 or 10 miles. Ages ago the valley was converted into a vast lake during the time of inundation, and when the waters receded the work of irrigation was done. Nothing could be more simple than this process, but it was not without disadvantages. Consequently it is not surprising to find that attempts to regulate the flow of the river were made at a very early epoch. In the time of Menes, the founder of Dynasty I., a dyke was built on the western side of the Nile, and transverse dykes were made connecting this work with the Libyan hills. In this manner a series of basins was formed, into which water was admitted through simple regulating channels in time of flood, excess water being afterwards returned to the river. On a portion of the land reclaimed by means of the main dyke, the city of Memphis was built. In succeeding dynasties further dykes were constructed, until much of the river was embanked on the western side, where also the capital cities of early dynasties were founded. The development of the western side of the valley, and the increase of population, no doubt suggested the reclamation of lands on the opposite side of the river. An operation of this nature clearly required the greatest caution, as well as a considerable amount of engineering skill; for if the river had been suddenly confined to its bed there would have followed the certainty of disastrous floods in low-lying districts beyond. The difficult nature of the problem was evidently realised by the engineers who were employed by Amenemhat III. to reclaim the eastern side of the Nile valley.

As a preliminary precaution, the natural opening leading to the Fayum was enlarged and deepened so as to form an adequate overflow, or "escape," through which the surplus waters of the Nile flood were led to the huge basin beyond, thus forming the reservoir known as Lake Mœris. For the proper control of this regulating area, an escape channel appears to have been made so that the lake might be partially drained off into the Nile after the flood had subsided, while both the inlet and the outlet channels were provided with solid earthen dykes, which had to be cut and again rebuilt whenever the flood required regulation. This great undertaking was the most successful of its kind ever executed in Egypt, and was justly regarded as one of the ancient wonders of the world. When the Nile had once been confined by embankments, in the manner described above, the natural consequence would be for the channel to become deepened until, at last, the time arrived when Lake Mœris could be drained and reclaimed. This operation seems to have been carried out in the time of Ptolemy Philadelphus, about 283—247 B.C., when the water surface was reduced to an area approximately equal to that of the present lake. By the agency of engineering works, such as we have very briefly described, the appearance of the Nile was greatly changed, and instead of existing as a shallow and wide-spreading expanse of waters it assumed the character of a deep and clearly-defined river flowing between high banks.

A notable work, probably executed in the time of the Pharaohs, was the canal known as the Bahr Yusûf, or "River of Joseph." The ruler, after whom this great waterway is named, was not the Joseph of biblical fame, but El-Melik En-Nasir Salad-ed-deen Yusûf Ibn-Eiyub, more generally known as Saladin, who restored the canal during the twelfth century. It is stated by Strabo that the Bahr Yusûf was employed in the early days of the Christian era for the conveyance of water into Lake Mœris as the flood rose, and away from it as the waters subsided, and that lock-gates then existed for the purpose of regulation. So far as the main features of the Bahr Yusûf are concerned, it may be said that the original course extended over about 350 miles, from Farshût to Cairo, connections being made with the Fayum on one hand and the Nile on the other. Within com-

paratively recent times the Bahr Yusûf was so neglected as to become dry in places, and to be generally unnavigable, except during the season of inundation. We need hardly say that, since British engineers assumed control of irrigation works in Egypt the greater part of this important waterway has been thoroughly restored, although its original course cannot be completely traced upon modern maps. At the present time the Bahr Yusûf runs from Deirût to the Fayum, and just outside the opening in the Libyan hills a branch canal runs down to the river, parallel with which a succession of canals and the channel of an old watercourse extend to Cairo. Between Asyût and a point below Deirût is the old channel of what is now named the Sohagiyeh canal, this disused watercourse being evidently the continuation of the Bahr Yusûf. Again, between Asyût and Sohag we have the existing Sohagiyeh canal, while between Sohag and a point on the Nile opposite Farshût a succession of canals is found, serving to suggest the original course of the Bahr Yusûf. The most important canal in Upper Egypt is the Ibrahimiyeh canal, commencing at Asyût and running parallel with the river to a few miles below Benisuef. Above Farshût canals continue successively along the Nile up to near Gabel-es-Silsileh, above which place there are no canals of importance. On the eastern side of the Nile we find constant succession of canals, but of less magnitude, owing to the fact that the Arabian Desert approaches very near to the river for the greater part of the distance between Aswân and Cairo. Although reference has only been made to the chief watercourses of the Nile Valley (Fig. 13), there is a tremendous network of smaller canals all over the cultivable lands of Upper Egypt, and the whole country is divided up into basins, or "hods," to which water is distributed in accordance with the regulations of the Irrigation Department. Water is retained in the basins for the purpose of irrigation by means of dykes, the time of inundation being about 45 days every year, and the depth of water varying from 1 ft. to 10 ft., with an average of about 4 ft. During the process many villages are connected by the dykes only, and others are cut off from communication except by boats. The mean difference between the highest and lowest levels of the river varies from point to point, being about 25 ft. just above Cairo, 38 ft. at Thebes, and 49 ft. at Aswan. The beds of the main canals are about 15 ft. above the bed of the Nile, and each canal generally has to serve seven or eight basins, the last of which is called a "tail" basin. The level of the cultivated land is about 15 ft. above the beds of the canals, and the basins vary very much in area. Those in narrow parts of the valley do not average more than 2,000 acres, while in the wider parts 20,000 acres is not an uncommon size, and some of the tail basins are fully 40,000 acres in extent. As in the Delta, many of the main canals are of gigantic proportions, the greatest width being about 250 ft., while the average may be taken at about 30 ft.; and the discharge varies from 5,000 gals. to nearly 100,000 gals. per second. In order to illustrate the method followed in basin irrigation we give, in Fig. 14, a plan showing some new basins to the west of the Bahr Yusûf, in Minia Province. The double line at the right-hand of the map represents the main drain, the irregular black line next to this channel being the Bahr Yusûf. Water is admitted to the system through the Saqula main regulator, and passes through regulators shown in the banks of the various basins, finally discharging at the proper time by the tail escape. In many of the more perfect systems the canals and escapes are made to siphon under each other, and are designed in such a way as to permit of alternative supplies, providing for variations necessitated by the peculiarity of the Nile flood in any particular year. With comparatively small exceptions, the cultivated land in Upper Egypt is irrigated on the basin system; and, speaking generally, Upper Egypt is still waiting for perennial irrigation, which in due course will follow the construction of the Nile reservoir works.

Asyût was wisely chosen as the site of the second great barrage on the Nile, as may

readily be realised by considering the main facts relating to the canal systems of Upper Egypt. The eastern side of the Nile valley, with its succession of main canals taking off independently from the river, derives some benefit from the higher levels secured by the construction of the new works, but only in the case of the canals taking off water upstream of Asyût. On the western side of the valley the advantages gained are far greater, for not only are more ample supplies secured for important waterways like the Canal-el-Kasrah and the Canal-el-Sohagiyeh, both upstream of Asyût, but adequate means now exist for diverting the necessary volume of water, through the Ibrahimiyeh canal and the Bahr Yusûf, to the extensive and fertile regions downstream of Asyût. Much of the western valley, and the entire Fayum province depend upon the Ibrahimiyeh canal, a water-way which virtually supersedes the Nile in these parts of Upper Egypt. The direct function of the Asyût barrage is to augment the supply of the canal, the head regulator of which is immediately south of the new structure. By means of the increased supply, the existing perennial area in the lower parts of the Nile valley, and in the Fayum, will be more adequately served during the summer, and about 420,000 acres of basin land will be converted to perennial irrigation. The Asyût barrage is really a regulating bridge, although it is sometimes incorrectly described as a weir. Sir William Willcocks, who was responsible for the designs, took the Delta barrage as a prototype, avoiding the constructional defects and unnecessary architectural adornments of that work.

The Asyût barrage includes 111 openings, each 16·4 ft. wide, separated by intermediate piers, 6·56 ft. wide, and abutment piers at every ninth opening, 13·12 ft. wide. The piers, measuring respectively 42 ft. and 50·5 ft. in the direction of the river, are connected by masonry spans, and carry a 15-ft. roadway, as well as travelling winches and suspension appliances for the upper and lower regulating gates, each 8·2 ft. high, which are capable of holding up the necessary head of water during the winter and summer months. The total length of the barrage, of which a plan and elevation are given in Fig. 15, is 2,640 ft., and the height from the surface of the floor to the roadway is 41 ft., the total height to the top of the parapet being about 45 ft. A navigation lock (Fig. 16) is provided at the western end of the barrage, measuring 262·4 ft. long by 52·24 ft. wide, these dimensions being sufficient for the passage of the largest Nile steamers. As the river bed at the side of the barrage was known to consist of fine sand, care was taken to avoid the risk of any undermining action, and there is no doubt that the exceptional experience gained by Sir William Willcocks, when resident engineer at the Delta barrage, proved of service in this more recent work, the general construction of which is shown by Fig. 17. The foundation is a combined masonry and concrete floor 9·84 ft. thick by 86·92 ft., in the direction of the river extending from bank to bank of the river and laid throughout at the same level between two lines of cast-iron grooved and tongued sheet piling with hydraulic joints, the piles descending 13·12 ft. below the bottom of the concrete floor. The whole of the foundation is built of Isawiyeh stone laid in cement mortar, and the superstructure of the same material in homra and lime mortar. As originally intended, the foundation, with the exception of the lower concrete bed, and the superstructure were to have been of brick, but it was found that the clay available near the site would be unsuitable for brick-making, and stone was consequently substituted. On the upstream side of the barrage there is an apron of clay puddle for the purpose of preventing infiltration, and above the apron stone pitching is laid for a distance of about 66 ft., with the double object of protecting the apron and of guarding against erosion of the river bed. On the downstream side there is an "inverted" filter bed for arresting sand in case percolation should occur, and over the filter pitching is carried for the same distance as that on the upstream side.

In carrying out the works the general method was adopted in successive seasons of laying bare portions of the river bed by the aid of temporary dams and centrifugal

FIG. 16.—NAVIGATION LOCK, ASYÛT BARRAGE.

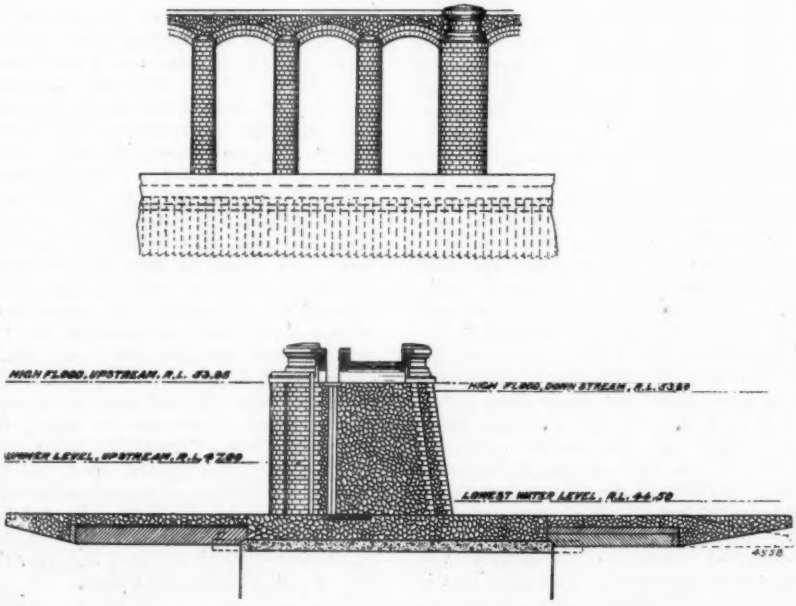

FIG. 17.—ELEVATION AND SECTION, ASYÛT BARRAGE.

pumps. This process could not well be attempted before the subsidence of the flood about the end of November; and the idea was that before the end of the following July a section of the floor should be laid, and the corresponding portion of the superstructure carried up to a sufficient height above the summer level of the river. By adopting this plan it was believed that building could be resumed in the next season without the delay and expense that would otherwise be entailed by reconstructing the temporary dams and again pumping out the water enclosed.

On December 1, 1898, the construction of temporary dams, or "sadds," was commenced. More than 128,000 cub. yds. of material, and nearly 290,000 sandbags were used in the making of the sadds, and early in February, 1899, pumping was commenced. About 13 acres of the river bed were speedily laid bare, and upon this site the foundations of the lock, and of 29 regulator spans were set out. On March 2, pile-driving was started, concreting and masonry being commenced early in May and continued both by day and by night until the first week in August, when the rise of the flood made it necessary for the sadds to be cut. Some idea of the magnitude of the operations conducted may be gathered from the following summary of quantities :—

Cast-iron piles	762	lin. yds.
Concrete and masonry in floor	38,572	cub. ,,
Masonry above floor ...	10,076	,, ,,
Pitching and clay puddle ...	40,197	,, ,,

Numerous springs of water appeared over the whole area of the season's work, but as grouting pipes had been formed over the more important springs, it was comparatively easy work to close all the cavities before operations were abandoned.

As the flood of the season 1899-90 was a very poor one, an early start was made upon sadds at the western side on November 23, those at the eastern side being commenced on December 5. A great effort was made to complete the entire remaining portion of the foundations during the season, and the attempt was very nearly successful. The piles on the up-stream and down-stream sides of the floor had been successfully driven right across the river, but owing to a breach in the sadds caused by the rising flood, work had to be abandoned on July 23, leaving a gap 66 ft. long where the floor had not been started, and about 352 ft. of the floor only partly built. The navigation lock was finished, with the exception of fixing the gates and the swing bridge, twenty-seven piers were carried up to the full height, forty-three others were up to three-quarter height, and nineteen others well above summer level. Thus nineteen piers remained to be built. The following is a summary of the quantities relating to the work of the season :—

Cast-iron piles	1,365	lin. yds.
Concrete and masonry in floor	61,502	cub. ,,
Masonry above floor ...	35,094	,, ,,
Pitching and clay puddle ...	69,577	,, ,,

In addition to the above, it may be added that material in sadd making amounted to 307,466 cub. yds., besides 1,462,000 sandbags, while 562,493 cub. yds. of excavation and filling were performed, and 122,666 cub. yds. of material were removed by dredging. The number of men engaged upon the works varied from 8,000 in the first three months of the year to 13,000 in May and June, and the work accomplished during the season 1899–90 was equivalent to about one half of the barrage. Springs again occurred over the site, and were treated in the manner before-mentioned. Alterations in the natural condition of the river took place during the flood of the season to which we now refer, for the deep channel moved towards the eastern bank of the river, while a sandbank on the western side had increased in width, closing the former west channel and covering the completed floor of the barrage with silt. Later in the season the east channel was closed by sadds, and a new channel was opened up across the floor of the barrage at a point where two piers had purposely been left unbuilt. After the end of July, navigation became practicable through the lock and over the tops of various unfinished piers.

(To be continued.)

The Commercial Development of Inventions.

By G. W. de TUNZELMANN, B.Sc., M.I.E.E.

In FEILDEN'S MAGAZINE of December 1901, the present writer propounded in the Editorial columns, under the title "Inventions and the Manufacturing Trade," the outlines of a scheme for the commercial development of inventions. This had gradually taken shape in his mind, as a result of the experience gained in advising inventors and capitalists interested in the development of inventions, and also in surmounting the numerous difficulties which he had encountered in the course of placing some inventions of his own upon the market.

The scheme consisted essentially in the formation of a strong financial corporation for the systematic selection and development of inventions; and it was suggested that provision should be made to allow of every manufacturer of repute becoming a member of the corporation. The lines on which it was proposed to work may be seen from the following extract from the writer's original article referred to above.

"There are at present men in London who, by taking up carefully selected inventions, and working them, or placing them on the market, have enriched themselves and benefited the trade of the country, and some at least of them have at the same time earned a reputation for treating every inventor with whom they have had dealings, not only fairly, but generously. What has been done by a few on a comparatively small scale could be done still more effectively on a large scale by a powerful association, preferably composed, to a large extent at any rate, of men with a considerable stake in the manufacturing trade of the country. The methods adopted would simply be an extension of those already successfully tested on the smaller scale. The association would have at their disposal the services of technical and commercial experts in all the various branches of industry, and arrangements would be made for the trial of such as passed the ordeal successfully either at the works of members of the association, for which they should, of course, be adequately remunerated, or elsewhere, as might prove most convenient in each case."

The proposals outlined above were favourably received and commented on by leading organs of the press, and a large number of letters on the subject were received by the editor of FEILDEN'S MAGAZINE. Most of these expressed sympathy with the project, but others contained adverse criticism, and some of them went so far as to maintain that the scheme was an attempt at realising the impossible. The most common objection raised was that the rivalry among manufacturers in the same line of business was so great that most of them would much rather incur a heavy expenditure in order to get hold of an invention giving them an advantage over their competitors, than secure, by a moderate outlay, a general advance in their special branch of industry, which would equally benefit their rivals, provided they happened to be members of the corporation.

The matter was further discussed in leaders, by the editor, in FEILDEN'S MAGAZINE of January 1902, and by the present writer in the March issue of the same year.

These articles have hitherto led to no practical result, but the subject has been again brought forward in a very able paper by Mr. James Swinburne, the President of the Institution of Electrical Engineers, published in *Page's Magazine* of December last year.

This paper was written quite independently, and was, as a matter of fact, actually in print before Mr. Swinburne had seen the articles referred to above in FEILDEN'S MAGAZINE.

Mr. Swinburne's proposals are formulated in the concluding paragraph of his paper as follows:

"What is wanted, is a strong financial concern which will develop inventions on terms that are fair to both parties. Such a concern should never

put a large proportion of its capital into any one thing, and it should be advised by competent specialists as to both technical and financial questions. The experts should be technologists, not unpractical people, and should hold shares in the concern. Such a house could make terms with an inventor at any stage of the development of his invention. At first the inventor has generally inflated ideas, but they always cool down in contact with financial difficulties. Such a concern as this, managed on business lines by really technical business people, would develop enormous industries, and make an immense amount of money; but it would have to be managed by people who had enterprise, were not led like sheep by City opinion, decided quickly, dealt honourably, and were technical business men."

It will be seen that these proposals differ from those put forward by the present writer in one point only, but that is an important one. The writer proposed the formation of a strong company, to be worked on commercial lines it is true, but to be at the same time something more than a mere commercial company—namely an Association of British Manufacturers working together for the benefit of the industries of the country. The course of events has shown that the latter portion of the writer's project was too Utopian for realisation under existing conditions. The matter is very well summed up in the following extract from a leading article in *Electrical Investments* of December 17th, last year:

"Nothing practical came of the suggestion made in FEILDEN'S MAGAZINE, probably because the proposed association of manufacturing interests was rather Utopian. It was hoped that the natural jealousies of manufacturers would be sunk in the face of the national necessity for making the best use of the inventive faculty of our countrymen, but the manufacturers did not respond. It is notorious that the characteristic attitude of the English manufacturer is conservative just as that of the American manufacturer shows an almost too eager desire for novelty. Moreover, it is a common plan for a manufacturer to purchase patents which threaten to supersede his particular methods or products, and to pigeon-hole them simply in order to prevent these particular patents from being worked. The policy is short sighted, of course, and not too creditable. But it is a recognised policy, and is only one of the many practical obstacles to the formation of the suggested association of manufacturers.

"If the manufacturers will not be united by a beneficent ideal, there remains Mr. Swinburne's suggestion to form a strong independent company, worked on purely commercial lines for a purely commercial end. This appears much more feasible, much more likely to be realised. There is a chance of very high profits to such a company, if adequately financed and ably worked. If the amount of money which is scattered about in promotion and pioneering expenses by innumerable small syndicates (many of them attempting to develop inventions which a well-advised concern would never take up) were concentrated in one company, sufficient funds would be provided to give the venture a full chance of success. The waste of capital is often considerable, and the waste of good ideas is also unhappily great. It is therefore to be hoped that the idea so forcibly expounded by the President of the Institution of Electrical Engineers, and endorsed by others who have a close practical acquaintance with the commercial side of scientific development, will ere long bear fruit."

It is unnecessary to comment in detail upon the trenchant manner in which Mr. Swinburne sets forth the difficulties encountered by an imaginary inventor endeavouring to commercially develop his invention according to the methods now in vogue, for every reader interested in the subject will doubtless peruse the paper for himself; and he will find himself well repaid for so doing.

The development of a really comprehensive scheme on a purely commercial basis should be sufficiently attractive, simply from the point of view of the large profits to be realised, to enable the requisite capital to be obtained. Over and above this, however, there are further inducements which the development of such a scheme offers to the wealthy and ambitious capitalist.

If carried out with ability and at the same time with due regard to the interests of the national industries, it would confer such great benefit upon the country that no honours could be considered too great for the man whose wealth and enterprise was successful in bringing it to the stage of realisation.

The Colonial Office Conference and Preferential Trade within the Empire.

By JOHN B. C. KERSHAW, F.S.S.

Introduction.

THERE is a disposition in some quarters to regard the Conference between Mr. Chamberlain and the Colonial Premiers, held in August last, as a failure in so far as it related to the promotion of trade within the Empire. The contents of the recently-published Blue-book dealing with the subject do not lend support, however, to the views of those who hold this opinion. It is true that no changes in the fiscal system of this country or of the individual Colonies were definitively settled upon, but the tone of the Conference was distinctly in favour of the promotion of closer commercial relations between the Mother-country and her offspring. Mr. Chamberlain's opening speech contained the following striking paragraphs on this point :—

"The first salient fact is this : that if we chose —that is to say, if those whom we represent chose —the Empire might be made self-sustaining. It is so wide, its products are so various, its climates so different, that there is absolutely nothing which is necessary to our existence, hardly anything which is desirable as a luxury, which cannot be produced within the borders of the Empire itself. And the second salient fact is : that the Empire at the present time, and especially the United Kingdom, which is the great market of the world, derives the greater part of its necessaries from foreign countries, and that it exports the largest part of its available produce, surplus produce, also to foreign countries. This trade might be the trade, the inter-imperial trade, of the Empire . . . .

"Our first object, as I say, is free trade within the Empire. We feel confident—we think it is a matter which demands no evidence or proof—that if such a result were feasible it would enormously increase inter-imperial trade, that it would hasten the development of our Colonies ; that it would fill up the spare places in our lands with an active, intelligent, and industrious, and, above all, a British population ; and that it would make the Mother-country entirely independent of foreign food and raw material."

The Conference ended with the understanding that the Colonial Premiers should obtain the consent of their respective Governments to systems of preferential duties designed to promote inter-imperial trade on the lines suggested ; and Mr. Chamberlain was careful to point out that something more than the Canadian 33 per cent. reduction on duties, initially much too high, will be required if useful results are to follow. The Colonial Secretary also intimated that, when the trade in manufactured goods between the home country and the Colonies had been developed along these lines, then, and not until then, it would be necessary to discuss the question of imposing reciprocal duties in favour of colonial produce in this country.

Since the principle of preferential trade has been thus endorsed by those taking part in the Colonial Office Conference, it will be of interest to examine some of the recent trade figures bearing on the subject.

The figures used in preparing this article are official. They have been taken from the "Annual Navigation and Trade Returns of the United Kingdom," and from the "Statistical Abstract for the Colonial and other Possessions of the United Kingdom," for the year 1901. These are both Board of Trade publications. The figures given in the latter cover the period 1886 to 1900. The three questions which demand answers are the following :—

I.—Is the trade of the United Kingdom in goods of home manufacture advancing or declining ?

II.—Does the British Empire produce at present sufficient food for its population ; and, if not, can it be made self-supporting in this respect ?

III.—Does the British Empire provide at present a sufficient market for the surplus manufactured goods of the United Kingdom ?

I.—Is the Trade of the United Kingdom in Goods of Home Manufacture Advancing or Declining?

The only figures which can be usefully employed in an attempt to answer this question are those representing the values of the imports and exports of manufactured goods for the United Kingdom.

There is no accurate means of determining the internal trade of the country. bankers' Clearing House returns, bank deposits, and income tax yields have often been used to prove that the country is still wonderfully prosperous. None of these furnish, however, an exact criterion of the value and volume of the internal trade of the United Kingdom. The figures for the external trade, on the other hand, are easily available. Their accuracy is often challenged, but the system of collection and valuation of exports and imports undergoes few variations, and the *relative progress or retrogression in any series of years* can be proved by use of these figures, even though they may not be absolutely correct.

The values of the imports and exports of *manufactured* goods by the United Kingdom for the period 1893—1900 are presented in tabular form below.

TOTAL VALUES OF THE IMPORTS AND EXPORTS OF MANUFACTURED GOODS BY THE UNITED KINGDOM.

Year.	Imports.	Exports.
1893	£72,100,100	£189,809,000
1894	75,200,000	184,647,000
1895	82,100,000	195,736,000
1896	88,000,000	209,832,000
1897	91,000,000	200,824,000
1898	92,400 000	199,075,000
1899	97,000,000	215,158,000*
1900	98,700,000	226,465,000*
1901	.....	..... *

At the first glance these figures may be held to justify the contention of those who claim that our manufacturers are more than holding their own. Our imports of manufactured goods have increased in value by twenty-six and a half millions in the seven years, but in the same interval of time the value of our exports of similar goods has gone up by thirty-six and a half millions. Comparisons of trade returns for single years are, however, never trustworthy, owing to the alternate periods of boom and depression which are experienced in all countries. The year 1900 was the culminating year of a well-marked boom, and the comparison of the trade returns for this year with returns for previous years leads to much too favourable conclusions. The only safe course with figures for trade returns is to employ averages covering three, five, or ten year periods; and if the shorter periods be selected, to see

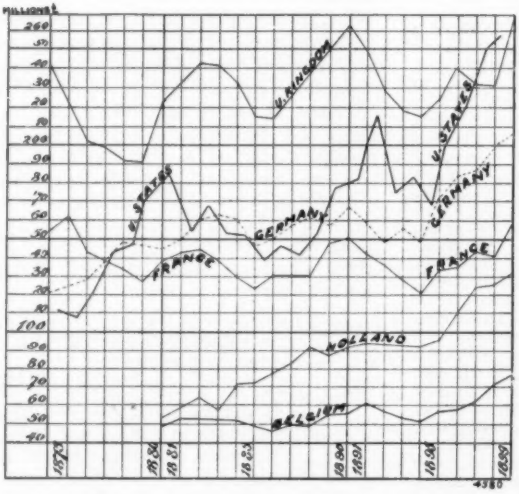

DIAGRAM I.—ANNUAL EXPORT VALUES FOR THE CHIEF MANUFACTURING COUNTRIES DURING THE LAST QUARTER OF A CENTURY.

Each vertical division equals ten millions sterling; each lateral division one year.

* The values of new ships have been deducted in 1899 and 1900, because not included in the earlier returns.

that years of boom and depression are not compared together.

Taking quinquennial averages for our total export trade, and extending our inquiry back to 1870, we obtain the following figures for the years 1871, 1881, 1891, and 1899—all years of comparatively booming trade.

Year.	Quinquennial Averages for Total Value of British Export Trade.
1871	£224,800,000
1881	226,000,000
1891	240,800,000
1899*	255,400,000

The enthusiast for the maintenance of our Free Trade policy may still find comfort of a moderate kind in these figures, for they undoubtedly show growth —even though that growth be slow.

When these returns are worked out as values per head of the population, the Free-Trader who has not allowed his belief in Free Trade to warp his judgment must admit that ground for satisfaction no longer exists. The population of the British Islands at the 1871 census was 31,845,000. It has steadily grown since that year, and in 1899 the estimated population (based on the 1901 Census returns) was 41,100,000. Using these figures we find that the value of our export trade in £ sterling per head of the population has actually *fallen* in the last thirty years from 7·07 to 6·21, and the assertion of those who claim that our position as a manufacturing nation is being successfully undermined by our rivals is fully proved.

If further proof that we are losing our industrial position be required, it may be found in the figures presented by Sir Alfred Bateman in the recently published Memorandum upon the Comparative Trade Returns of the United Kingdom and some leading foreign countries (Board of Trade publication, 1902).

On page 20 of this Memorandum a tabular statement is given, showing the average annual value of the imports of thirty neutral countries from the United Kingdom, Germany, France, and the United States, for the two periods 1893–95 and 1898–1900; these values being expressed as percentages of the total trade.

Although the year 1900 was a year of booming trade in the United Kingdom, the figures show that the trade of this country is declining when compared with that of its chief rivals. Expressed in percentages of the total trade for each importing country, we find that the changes in the value of the British trade in the periods named involved gains equal to 26 points in the case of nine of the importing countries, *and losses equal to* 83 *points in the case of seventeen countries*, while our trade with the remaining five countries remained in a stationary position. *The net loss was therefore* 57 *points.* In other words, between the years 1893 and 1900 our chief rivals have been increasing their export trade with neutral markets more quickly than we ourselves. Sir Alfred Bateman is pleased to regard the position reassuring, because we

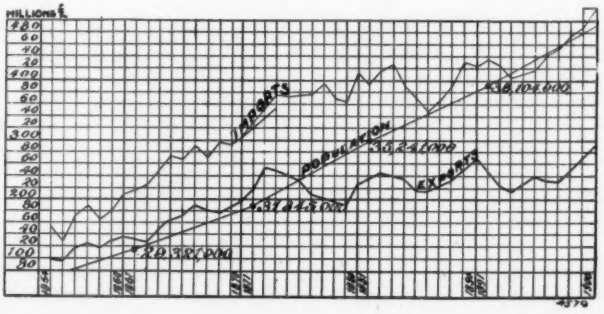

DIAGRAM II.—ANNUAL EXPORT AND IMPORT (REAL) VALUES FOR THE PERIOD 1854-1899.

The straight line shows the increase of population during the same period. Each vertical division is equal to twenty millions sterling; each lateral division to one year.

* This is the last year for which a quinquennial average can be calculated.

still retain a preponderating position. Would he be equally pleased with the situation were we trading under a protective tariff? One can imagine the striking use that would be made of these figures by Sir Alfred Bateman and the Cobden Club under such circumstances. If these losses continue, how long shall we retain the largest share of the trade with neutral markets?

I may summarise the facts given in this section of my article by the following statement:—

The United Kingdom in 1871 *reached the zenith of its growth as a manufacturing country under free-trade conditions, and since that year there has been a slow but steady decline in its productive power. There is consequently every reason for giving serious consideration to the question whether the time for some change in our fiscal policy has not now arrived.*

II.—Does the British Empire produce at present sufficient Food for its Population; and, if not, can it be made self-supporting in this respect?

The figures which have been utilised for answering these questions are based upon the official returns given in the two Board of Trade publications already quoted. It is customary for writers on this subject to confine their attention to the figures representing the present export of food stuffs from the Colonies to the Mother-country. This method is incorrect. A certain proportion of the food produced in the Mother-country and her Colonies is at present diverted to markets outside the Empire. Under more favourable tariff and freight conditions this would be consumed within it.

In order to judge of the present and future possibilities of feeding the populations under the British flag by products of the Empire, it is therefore necessary to take into account the value of the food-stuffs exported at present to foreign countries. The following totals are based on the values of the *Total Food Exports* of the United Kingdom and of the various Colonies and Dependencies of the Empire. The figures cover the eight years 1893–1900. They show that, whereas in the year 1893, 34 per cent. of the food imported into the United Kingdom could have been obtained within the Empire, in 1900 the proportion had slightly improved, the percentage being 35·4 per cent.

TOTAL VALUES OF THE FOOD EXPORTS OF THE BRITISH EMPIRE, AND IMPORTS OF THE MOTHER COUNTRY

Year.	Total Exports of the Empire.	Total Imports of the United Kingdom.
1893	£59,562,000	£175,300,000
1894	56,668,000	172,870,000
1895	53,221,000	174,266,000
1896	55,934,000	183,006,000
1897	56,886,000	189,621,000
1898	65,196,000	204,116,000
1899	77,679,000	204,646,000
1900	76,283,000	215,370,000

The answer to the question is therefore in the negative—*the British Empire does not at present produce sufficient food to feed its population.* This at once leads us to ask—Must this position of dependance upon foreign countries for food continue? Personally, the writer does not think so. There is no doubt that, under more favourable conditions as regards freights and tariffs, the trade between the Mother-country and her Colonies in food-stuffs could be enormously increased. Canada and New Zealand possess some of the finest wheat-growing land in the whole world, and Prof. James Long has estimated that 55,000 farmers, settled on 100 acre farms in Canada alone, could supply our deficiencies in this respect. This settlement of the best wheat-growing lands in the North-West provinces of Canada is already taking place by emigration from the States, but it would have been more satisfactory if the new-comers had been of home, instead of American, origin. The following figures, showing the value of the total food exports of Canada for the eight years 1893–1900, are of interest, as they show the rapid agricultural development which is even now occurring in that portion of His Majesty's dominions:—

TOTAL VALUES OF THE FOOD EXPORTS OF CANADA TO ALL COUNTRIES.

1893	£11,592,000	1897	£12,769,000
1894	12,391,000	1898	18,645,000
1895	10,652,000	1899	17,085,000
1896	10,953,000	1900	18,995,000

An increase of over 50 per cent. in eight years is a startling indication of the agricultural possibilities of Canada. Should a preferential tariff system be inaugurated for British products, the growth of Canada as a food-producing country will be still more rapid in the future.

Australia and New Zealand likewise show considerable growth in recent years in the value of their food exports, and the figures given below are highly instructive as to the influence that more favourable tariff and freight regulations might have upon the agricultural production of this quarter of the Empire.

TOTAL VALUES OF THE FOOD EXPORTS.

	1893	1897	1900
	£	£	£
Australia.....	7,151,000	7,726,000	11,250,000
New Zealand	2,151,000	2,406,000	4,145,000
Totals.....	9,302,000	10,132,000	15,395,000

The increase in eight years is nearly 62 per cent., and is still greater than that shown by Canada.

While, therefore, the United Kingdom is still dependent upon foreign countries for nearly two-thirds of its food supply, the figures show that a rapid agricultural development is occurring in two quarters of the Empire. This development only waits the adoption of a preferential tariff system in order to be still more marked.

There is little doubt, were such a system once inaugurated, that the population of the United Kingdom by 1915 *could be supplied with a sufficient quantity of food, grown within the Empire, at a cost little in excess of that at present ruling.*

III.—Does the British Empire provide at present a sufficient market for the surplus manufactured goods of the United Kingdom?

The total values of the exports of manufactured goods by the United Kingdom have been obtained from the Trade and Navigation Returns of the Board of Trade. The figures for the past eight years are as follows:—

TOTAL VALUES OF MANUFACTURED GOODS EXPORTED BY THE UNITED KINGDOM.

1893	£189,809,000	1897	£200,824,000
1894	184,647,000	1898	199,075,000
1895	195,736,000	1898	215,158,000
1896	209,832,000	1900	226,465,000

The values of *new ships* have been deducted in 1899 and 1900, because not included in the earlier returns.

The above figures show an increase of £36,600,000 in the eight years, equal to a gain of 19 per cent.; but the value of our export trade varies greatly in successive years, and comparisons of individual years are never trustworthy.

Turning now to the figures representing the value of the total imports of manufactured goods by our Colonies and Dependencies, we find that if the *imports* of similar goods by the United Kingdom be included, the answer to our inquiry is in the affirmative—*the Empire does at*

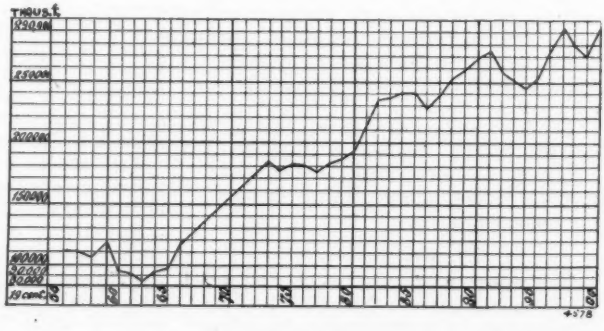

DIAGRAM III.—ANNUAL VALUES OF THE EXPORTS OF THE UNITED KINGDOM FOR THE PERIOD 1856-1900, AT THE PRICES OF 1881.

The curve thus represents the fluctuation in the volume of our export trade. Each vertical division equals ten millions sterling; each lateral division one year.

present provide an adequate market for the surplus manufactures of the United Kingdom. The detailed figures are given below—for the reasons already given, totals covering a series of years being employed.

TOTAL VALUE OF THE IMPORTS OF MANUFACTURED GOODS, BY THE VARIOUS DIVISIONS OF THE BRITISH EMPIRE, IN MILLIONS STERLING.

1893	£189,135,000	1897	£230,999,000
1894	174,675,000	1898	227,879,000
1895	195,206,000	1899	246,675,000
1896	219,839,000	1900	266,088,000

The figures for the latest year for which returns are available (1900) show that the Empire, as a whole, imported £40,000,000 *worth more goods* of this description than were exported by the United Kingdom, the exact totals being £266,088,000 and £226,465,000 respectively. The increase in the eight years has been over £76,000,000, and there is consequently little doubt that the present demand for manufactured goods by the British Empire is in excess of its producing power.

The visions of those who see this country filled with deserted mills and factories and starving operatives as a result of any attempt to restrict British trade to British channels of supply are therefore wholly false. It is the result, not of a serious study of the figures bearing on the subject, but of preconceived ideas as to the value of the colonial trade.

Were not one pound's worth of our goods sold outside the countries over which the British flag is flying, our manufacturers would still have a larger trade than is theirs to-day.

The inauguration of a preferential tariff system for the Empire is therefore a change in our fiscal policy which would tend to benefit, rather than to endanger, our home industries.

IV.—Conclusions.

The writer may claim to have proved by the figures given in this article that the assertions made by Free-traders regarding the security of our present position as a manufacturing nation, and the appalling dangers that are involved in tariff changes, are wholly fictitious.

Our present position is not secure: it is highly insecure. Our exports per head of the population have declined steadily in value since 1870, and are still declining. In 1900 and 1901 we imported nearly £100,000,000 of foreign manufactured goods, and the United Kingdom is becoming each year more of a "dumping-ground" for the surplus products of Germany and America. Only those who have made Free-trade into a fetish can assert, in face of these facts, that all is well.

The appalling dangers that are involved in any change in our fiscal policy are likewise the creation of the disordered mental vision of Free-traders.

There is an adequate market at the present moment within the Empire for the whole of its output of manufactured goods. The demands of this market are rapidly growing. Should the whole of our present export trade to foreign countries be lost, our manufacturers would still have to increase their production by £40,000,000 worth of goods to meet the present demands of the Home country and of the Colonies and Dependencies of the Empire.

As regards the food supply of the population of the Empire, the figures show that we can at present produce one-third of this under the British flag, and that the proportion is slowly increasing. Here, again, the Empire provides an adequate market for all the food produced within it; and it will be years before the agriculturists of Canada and New Zealand have overtaken the demand for meat and grain. A preferential-tariff system would but accelerate this development of the food resources of the Empire.

Free-traders, in their slavish adherence to the underlying dogma of their policy—cheap food and cheap manufactured goods—forget that one must be a producer before one can be a consumer; and they are disposed to ignore the danger that under the present conditions of international trade (miscalled by them Free Trade) our Home and Colonial industries may be undermined and destroyed by protected industries in other lands.

In the opinion of many the time has

arrived when this danger must be recognised, and when steps must be taken by the Home and Colonial Legislatures to relieve the threatened industries from such unfair competition. Will the Colonial Premiers be able to induce their respective Governments to take action in this momentous question; and will the Home Government support them by imposing preferential duties on Colonial products?

The following extract from Mr. Chamberlain's speech at Birmingham on May 16th, 1902, proves that there is one member of the present Government who is alive to the dangers of our present position, and is prepared to take the steps necessary for increasing the over-sea trade with our Colonies:—

"At the present moment the Empire is being attacked on all sides, and in our isolation we must look to ourselves. We must draw closer our internal relations, the ties of sentiment, the ties of sympathy, yes, and the ties of interest. If by adherence to economic pedantry, to old shibboleths, we are to lose opportunities of closer union which are offered us by our Colonies, if we are to put aside occasions now within our grasp, if we do not take every chance in our power to keep British trade in British hands, I am certain that we shall deserve the disasters which will infallibly come upon us."

The Hewitt Mercury Vapour Lamp and Static Converter.

THE subject of our presentation plate this month is an experimental converter, which is the invention of Mr. Peter Cooper Hewitt, of New York.

This, together with a mercury vapour lamp, also the invention of Mr. Hewitt, were made the subjects of an interesting demonstration, given recently at the offices of the British Westinghouse Company, when amongst other notabilities, Lord Kelvin and Mr. George Westinghouse were present.

AN EXPERIMENTAL LAMP, SHOWING CONSTRUCTION.

The exhibition of the light in London is primarily due to the fact that the question of lighting the tunnels of the Underground Railway is now under consideration, and the want of satisfactory results attending the investigations made by the management of the District Railway resulted in Mr. Hewitt's apparatus being brought to this country to demonstrate the possibilities of his system for this purpose.

Although only in the experimental stage, the opportunity was taken advantage of to exhibit to people contemplating an extensive use of electricity the static converter, the future of which, when put into commercial shape, will, no doubt, be considerable.

With regard to the lamp. This, as its name implies, derives its light from the vapour of mercury, which, by the passage of an electric current, is raised to a high state of incandescence. It consists, as will be seen from the illustration, of a vacuum tube, the bulb of which contains the mercury, and constitutes the negative end of the lamp. The tubes may be of any size, from 3 ins. in length and $\frac{1}{4}$-in. in diameter to 4 yds. in length and 3 ins. in diameter—those shown in the illustrations are from 3 to 4 ft. long—the size of the tube regulating the range of illumination, which may vary from 16 candles to several thousand.

The lamps may be connected in series or in parallel, and may be operated on any direct current with a voltage of between 50 and 500. They will allow a regulation of as much as 10 per cent. variation. The current consumed may be varied from ·2 to 20 ampères.

The lamps reach their full candle-power almost immediately on starting, and give an absolutely steady light, the efficiency of which is about $\frac{1}{3}$-watt per spherical candle-power, and under favourable circumstances as high as ·3 watt per candle-power. The life of the lamp is theoretically unlimited, those tested showing only a slight falling off after being in use over 2,000 hours. By opening the tube, washing out, and re-exhausting, the lamp is restored to its original condition. There is very little radiant heat emitted, and the temperature of the glass is about that of an incandescent lamp globe.

In starting up, the voltage of an ordinary electric light circuit is insufficient to set up incandescence. Resort is therefore had to a special form of switch, which causes a high-tension discharge to take

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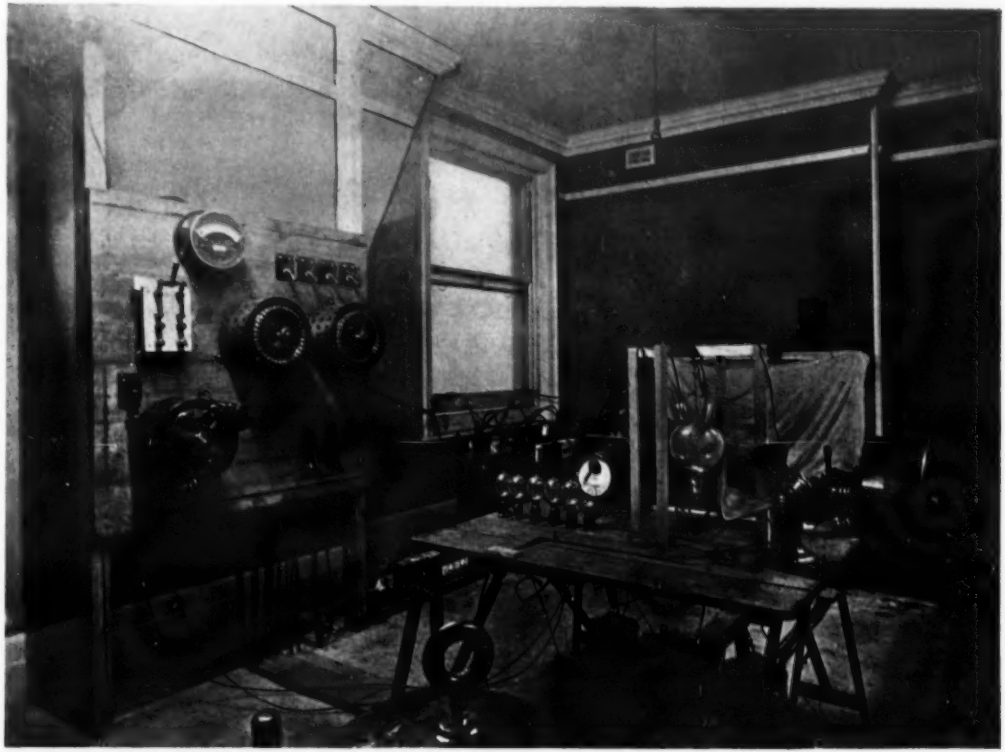

Room fitted for test of Hewitt Static Converter at the London Office of the British Westinghouse Co., Ltd.

IN CRANFORD, INC.

THE CRANFORD PRESS, CHISWICK, W.

place along the tube, which reduces the resistance sufficiently to permit of the use of a current at any voltage between 50 and 500.

The light emitted by the lamp is peculiar and characteristic, the absence of any red rays robbing it of its utility for all æsthetic purposes, causing objects appearing yellow by daylight to assume a greenish tinge, and generally producing a considerable distortion in colour values. We were unable to obtain a photograph of the spectrum of the light, but we understand that yellow and green largely predominate, the curve rising rapidly from the red end and falling less rapidly at the violet end, at which some diffused light is emitted.

The lamp may be employed to great advantage for purposes where a considerable illumination is required, and where, on account of its sharp and heavy shadow, the ordinary arc light is unsatisfactory. The extreme diffusion obtained, and the absence of red rays, renders it invaluable where an absolute comparison of true colour values is not required, as, for instance, in places where goods are handled; in streets and tunnels, and the interior lighting of machine shops, mills, drawing offices, etc.

One of the greatest fields of application of the lamp is in photography, by reason of the light being almost entirely composed of "actinic" or chemical rays.

It thus forms a satisfactory substitute for daylight, a fact which should commend it to all professional photographers. The accompanying photographs of the lamp and converter were taken by the light of one of the lamps.

Finally, by the use of certain dye stuffs in reflectors or screens, or by a combination with red lamps, a suitable light for general indoor illumination can be obtained.

Turning now to the converter, this remarkable invention was evolved by Mr. Peter Cooper Hewitt from his observations of certain phenomena in connection with his mercury vapour lamp, upon which its principles of operation are based. It is important to observe that this converter contains no moving parts.

Its purpose is to convert alternating current into direct current more simply, efficiently, and economically than by any other means that has yet been devised.

The reduction of potential presents no special difficulties, inasmuch as static transformers have been found to answer all requirements. Conversion of the alternating to direct current is, however, a problem less easily solved. The usual apparatus employed for this purpose is of

THE LAMP ALIGHT: A SNAP-SHOT TAKEN BY THE LIGHT OF THE LAMP ITSELF.

THE CRANFORD PRESS, CHISWICK, W.

two kinds—*i.e.* motor-generator sets and rotary converters, the latter machine being the equivalent of the motor and generator combined. Both forms of apparatus must be installed in stations, and require constant personal supervision. For economic reasons it is necessary to reduce the number of sub-stations as much as possible, with the result that they are separated by long intervals; and this necessitates the use of a large amount of heavy and costly copper cables as "feeders" for the further distribution of the current.

The elimination of the rotary converter and the present costly sub-station by a simple contrivance, which can be operated without constant supervision, and may consequently be inexpensively installed at more frequent intervals, is therefore a matter of the very greatest moment.

In its general construction the static converter somewhat resembles the vapour lamp, and it is even possible to combine the two, obtaining the brilliant mercury vapour light and also direct current for power.

Direct current may be obtained by means of the apparatus from either single or polyphase alternating current. Generally speaking, the invention may be described in the following words: A vacuum tube or bulb is supplied with a positive electrode for each phase of the alternating current, which successively permits the positive alternations of the current to flow to a single negative electrode common to the several positives.

THE HEWITT THREE-PHASE STATIC CONVERTER, SHOWING CONSTRUCTION.

Three terminals for three-phase + electrodes, extra terminal for direct current + electrode used at starting. Common − electrode at bottom of bulb.

Owing to the peculiar characteristics of the vapour column as a conductor, the current can pass in only one direction, and in consequence the alternations on one side of the zero line only will traverse between the electrodes. The alternations of opposite sign are cut off, and become inert in that they absorb no power.

The converter may be used on all voltages between 100 and 1,000, and can without further development be made for all capacities up to 100 ampères. Several converters, properly arranged, can be operated in parallel.

The efficiency of the apparatus is very high, the only loss in power being due to a constant drop of 14 volts in the bulb. Consequently, at 140 volts the loss is 10 per cent., at 700 it is 2 per cent., and at 1,000 only 1·4 per cent.

When the development, in a commercial stage, of this invention of Mr. Hewitt has been accomplished, it will probably be destined to fill a long-felt deficiency in electrical power supply.

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

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Temporary Repair to a Motor.

WHEN a single coil "burns out" in a motor, serious inconvenience may result and financial loss be incurred if it cannot be made to work again in a few hours. For such cases the following method may be resorted to with advantage. Find out how many coils are defective, by pressing one end of a wire againt a commutator segment and moving another wire round the commutator. Then bring an incandescent lamp or galvanometer and battery in circuit with the wires. If the armature is intact, the circuit through the lamp or galvanometer will remain complete. When the defective coil is met with, it will likely be broken. Unsolder this defective coil from the commutator lugs (as they are always earthed). If a testing set is at hand, test the insulation of the remainder. In the case of a ring armature, the ends of the faulty coil will be found in adjacent lugs; these should be connected by fixing a piece of copper between the lugs. The motor will then work as formerly, but it may not start if the brushes rest on the corresponding commutator segment. This defect is easily got over. In drum armatures of bipolar machines, the ends will be found diagonally opposite each other, so two lugs must be connected as before. Then the motor is analogous to a toothed wheel-gear with a tooth or two missing.

W. W.

Wanted—a Reliable Seal for Consumers' Electricity Meters.

Some engineers object to wires passing through holes in front of the set screws used for fastening the cover of the meter, for these may be split with a penknife (in halves) and the wires unfastened. Afterwards it can be easily pressed together again. Many prefer sealing-wax. This is excellent so long as it lasts. But when the covers expand, owing to a slight change of temperature, the sealing-wax is not affected to the same extent, so the hold it has on the covers gradually lessens. In time it becomes separated from it. Then someone cracks it, or does away with it entirely when dusting the meter.

1. As consumers' meters are left so much to take care of themselves, there can be no great objection to using a seal that cannot be readily removed even by the supply authorities.

2. The material of which it is composed must be brittle, so that it cannot be tampered with.

3. It must not be affected by time or moisture.

4. It should lend itself to being put on when the meter is *in situ*.

As there is unlimited demand for a satisfactory seal, a good reward awaits the person who devises it.

W. W.

A Hint to Meter Readers.

All meter readers have a grievance in the propensity some owners of premises possess for choosing awkward situations for their electricity meters. A common place is under a shelf or close to the ceiling of a cellar or passage. The meter readers are often required to turn on a few lights and note the number of lamps with which the meter starts, the number

required being a measure of its efficiency. They observe if the disc or index hand moves. For some makes the revolving element is not visible, so a hand is placed on the end of the spindle, which is visible through a little window in the top of the meter. Obviously, when the meter is fixed under a shelf or close to a ceiling this hand cannot be seen. This difficulty may be got over by placing a small mirror in a slightly inclined position over the window, when the index hand will be seen reflected in the glass. W. W.

Extension of Line Shafting—An Emergency Job.

Owing to alterations and extension of workshops, I required to continue the line shaft *A* (at a smaller diameter) about 200 ft. further to drive foundry machinery, and this connection was to be made without interruption to the existing arrangements. A ready and economical means of coupling up to the line shaft was my trouble, the bevel wheel came flush with the end of the shaft, which also was swelled at the end to receive the wheel. The extended portion was to be $\frac{1}{2}$-in. diameter less. I could have readily solved the difficulty by preparing a new piece of shafting about 32 ft. long, with a swell to receive the wheel, taking out the last length and dropping in this new length. But I did not want the expense of a new length, neither could I stop the running long enough to take out the last length, cut it, and connect on a short length to project through the wheel sufficiently to enable a coupling to be fixed to receive the new shafting. While turning it over in my mind, the thought occurred, "Why not make a coupling of the bevel wheel?" That looked like a "mechanical job." The following Saturday I proposed to do this. In the meantime I prepared one half of a flange coupling, bored $2\frac{1}{2}$ ins. diameter to suit the new shafting, and opened out the diameter for about $\frac{3}{16}$ in. up it at the flanged end, to suit swelled end in wheel, drilled the bolt holes, and cut the key-way. On Saturday, directly the shop engine ceased running, the bevel wheel was slipped off, put on a mandrel, the wheel centre faced and recessed $\frac{1}{16}$ full, to a diameter equal to the flange of coupling, on the side of the extended shafting. The prepared coupling was dropped into this recess, drilled right through, bolts fitted, marked, and taken off again. The bevel wheel was then replaced, and put in gear, as before, the whole job taking $3\frac{1}{2}$ hours. I was now in a position to prepare my new line of shafting at my convenience, and had a true face on the old line shaft to square off from. Figs. 1 and 2 illustrate before and after alteration.

WORKS MANAGER.

Wheel-Cutting on Milling Machine.

The sketch shown at Fig. 1 represents the axle and chain-wheel blank of a motor-car, both being in one piece. The wheel is about $6\frac{1}{2}$ ins., and the axle $2\frac{1}{4}$ ins. in diameter, the total length of both about 5 ft. 6 ins., the recess in the wheel end about $4\frac{3}{8}$ ins. diameter, and slightly taper. Having several of these wheels to cut.

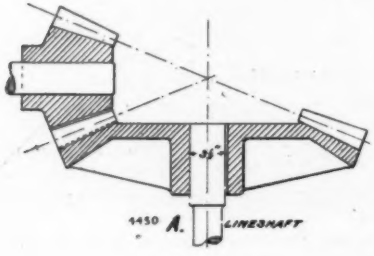


FIG. 1.

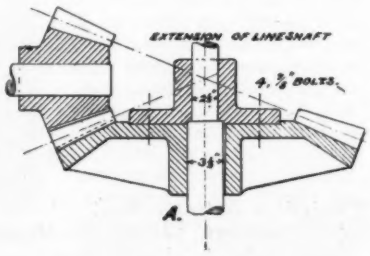


FIG. 2.

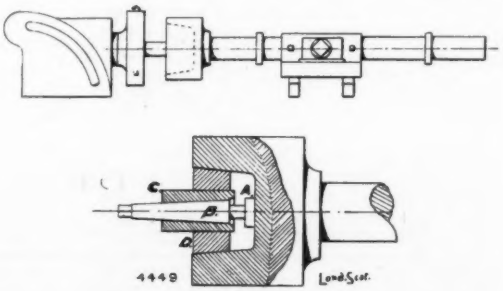
EXTENSION OF LINE SHAFTING.

and having no machine with table long enough to do so between centres, and the shaft being too large in diameter to pass through jaw-chuck and headstock, the difficulty was overcome in the following manner. The recess being only for lightening purposes, and of no particular dimensions, we had nothing existing to fit, so got a cast-iron bush turned to fit the taper, about 1½ in. long, with 1¼-in. hole, and this was sawn through to the bore to allow for expansion. The axle was stood on end, recess upwards, and a piece of packing *A* (Fig. 2), about 1 in. square and ¼-in. thick put at bottom of recess. On this the thick end of a taper mandrel *B* rested with 1¼-in. sleeve *C* on it; the bush *D* was then slipped over it. Having got the bush in the right position, the sleeve was driven down the mandrel, thereby expanding it, together with the cast-iron bush, and thus fixing it firmly in the recess *R*. With the jaw chuck on the dividing headstock, it could now be held by gripping the sleeve *C*; and to support and hold the shaft firm an ordinary milling machine vice was fixed on adjustable packings, and regulated so that when the shaft rested on the bottom of vice, and also against the fast jaw, it was perfectly parallel with the slots in table and also with the top of table. The vice was opened when the dividing had to be done, and closed before the cutting commenced. The cut taken was $\frac{1}{10}$ in. deep, and about an inch feed per minute, and held in the way described was as firm as if cramped on the table direct. In looking at Fig. 2, there seems an apparent difficulty in getting the bush and sleeve out of recess; but by giving the thin end of the mandrel one or two sharp blows with a hammer it causes the packing at the bottom to become loose, and by tilting the wheel to one side it will move from under the mandrel, which can then be driven down to the bottom and so loosen both the sleeve and bush, which can then be easily withdrawn.

C. H. G.

High-Speed Gas-Engines.

In the erection of gas-engines having one heavy fly-wheel and outside bearing, some difficulty is found in making all three bearings take equal weight, so that when running at high speed they will not heat, which generally necessitates the bedding down of the crank. I have found, with a little careful adjustment, this can in most cases be avoided with engines up to about 22 b.h.p., and gives every satisfaction. After placing the engine on the foundation, the top caps of the bearings being removed and all thoroughly cleaned, the crank shaft is then placed in the bearings. Take two strips of brown paper 1½ in. shorter than the journal, so to be clear of the radius, and 1¼ in. wide, about four thicknesses: this depends on the clearance the makers give the top caps. Place one on each bearing lengthways on the top of the crank shaft in the centre of the bearing; a little tallow will hold them in position. Replace the caps and tighten down carefully on both bearings, the shaft will then bed on both bottom brasses and be immovable. Now level and square up the engine, packing it at the low corners with flat pieces of iron, being sure that these take the weight. If lewis-bolts are used they must now be grouted in, and allowed to stand till set; the piping, &c. going on in the meanwhile. When the cement is hard, the bolts must be tightened down. Try the engine over again for being level and square. Now take the outside pedestal and, after cleaning, place it in position. Remove the top cap, and place a strip of paper, the same as in the main



WHEEL-CUTTING ON MILLING MACHINE.

bearings. This will secure the bearing and pedestal to the shaft, and lift it off the concrete, owing to the foundation on the first onset being left $\frac{1}{8}$ in. lower on this side. Now wedge up the four corners with iron wedges. See that they are not too keen, and that each takes the weight. The engine and pedestal are now ready to grout up. Do not disturb the wedges and packings. See that the grout is well mixed, and runs under the engine and pedestal. The cement when hard should be at least $\frac{1}{4}$ in. above the bottom of the castings, and slope down from all sides of the engine and pedestal, so that the oil will not remain, this having a tendency to rot the concrete round the beds. Remove the shaft when the cement is hard, and all the foundation bolts being screwed up, the fly-wheel and shaft can now be lowered into position, every care being taken to keep the journals clean and free from dust. It will be found that a scrape will not be required on these bearings, which will be a great saving of time and labour.

H. T. M.

Jig for Reversing Links.

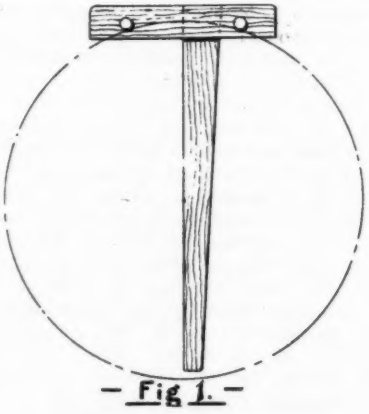
The jig consists of two double V-blocks, sliding in a guide plate, as shown in sketch. It is used for setting the links (double-bar type) for drilling at the ends, and thereby ensuring perfect alignment of the pins on both links. The links are first drilled out $\frac{1}{8}$ in. smaller than the finished size. This allows the holding-down bolts to be placed out of the way of the tool, when the edges are milled out to the proper curvature. The links are then set in the jig, and lightly clamped together. They are adjusted so that each pin falls well to the bottom of the V in which it rests, being tested by a feeler gauge. Then the links are clamped tightly, finally tested, and drilled and rimered out to the proper size. The guide-plate in which the V-blocks slide, prevents any inaccuracies which would be caused by lateral movement.

E. H. D.

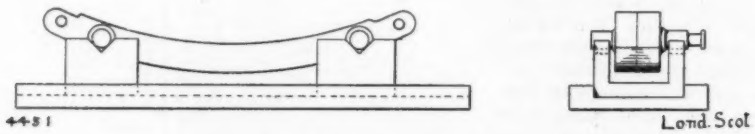
Converting a T-Square.

A very useful addition is made to the ordinary T-square, converting it into a radial square by the insertion of two pins set equi-distant from the edge of the stock and blade, as shown at Fig. 1. It is particularly helpful in locating the centre or drawing radial lines on circular plates of large size. No special size of pins is necessary, but it is essential to accuracy that the pins be of the same diameter.

F. SMITH.



CONVERTING A T-SQUARE.



JIG FOR REVERSING LINKS.

Engineering Abstracts

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CONSTRUCTION.

Wood Pavements under Heavy Traffic.

In a paper presented to the American Society of Municipal Improvements, the author draws attention to a paving block removed from Tremont St., Boston, after nearly two year's use under very heavy traffic. The surface of the block was almost as hard as stone, owing to the forcing of sand into the fibres under compression by traffic. The author shows that, when dry, wood pavements are not so slippery as asphalte, and when covered with frost, sleet, or slime, he believes the use of a grooved joint will provide a perfect foothold for horses. Only three forms of pavement are recommended for heavy traffic: granite block, wood, and asphalt, wood being recommended as the most economical and satisfactory. By laying the blocks with no gaps between them, a smooth surface results which has no vulnerable point to be attacked by the action of traffic, the action of which then is to compress the fibres so that the heavier the traffic the more solid becomes the surface of the block. It is then argued that suitable timber laid in this manner will form a surface which will wear without the slightest irregularity, and will prove to be possessed of a longer life than granite.—**F. H. Kummer,** *The Engineering Record, Oct. 18, 1902,* pp. 366, 367.

Graphic Representation of Elastic Strain.

The author puts forward a theory for the computation of elastic strains in triangular systems, such as are used in constructional steelwork. Two methods are generally in use for the solution of the problem; the older consisting in the application of the fundamental formula relating to strain in flexible prisms—$\frac{1}{\rho} = \frac{M}{EI}$ A newer and more convenient method, based on the consideration of elastic force, is that developed by M. Castigliano. Further, M. J. Resal explained in his work, "Stabilité des Constructions," a graphic method, which the author characterises as irreproachable from the point of view of exactness, but somewhat unnecessarily complicated. Being impressed with the importance of the problem, the author has evolved a new method for its solution, which is purely graphic, and requires only an elementary knowledge of graphic statics. His theory is based on the following theorem: "If the elastic forces, assumed to be less than the elastic limit, vary in a certain ratio throughout a strained body in a state of equilibrium, all changes of form will vary in the same ratio." Several examples are taken for the purpose of showing the application of the system, and the author believes that, if not so elegant as that of Castigliano, his method will be found to provide a rational method of computation, combining, as nearly as may be, theory with actual practice.—**J. Keelhoff,** *Proc. Ingénieurs du Gand, Oct.*

A Pipe-Arch Bridge.

Where crossing the Sudbury river, the steel-pipe conduit of the Metropolitan waterworks, Boston, U.S.A., will form an arch of 80-ft. span, with a rise of 5 ft. 6 ins. The pipe is built of steel plates measuring about 90 ins. by 290 ins. and $\frac{5}{8}$ in. thick. The abutments of the pipe bridge are to be of concrete faced with granite, and between them will be placed the pipe arch of 11 rings, in which all seams will be double riveted through drilled rivet holes. A light foot bridge with pipe railings is to be secured on top of the arch by angle brackets, but otherwise the bridge span will merely consist of the steel pipe. Reversed curves will of course be necessary in the pipe at each end of the bridge, and these curved portions of the conduit will be imbedded in the concrete of the abutments. In addition, they will be anchored down by means of 6-in. by 6-in. steel angle-bars riveted to the plates.—*Eng. Record, Vol. 46, Oct. 25, 1902,* p. 389.

A Protracted Job of Underpinning.

In consequence of the erection of a high steel-cage building for the bank of the State of New York, the underpinning of an adjoining brick building became necessary. The wall to which the work, now described, was applied is about 70 ft. high by 100 ft. long, and, including its floor load, weighs fully 1,600,000 lbs. Eight distinct stages

were observed in the underpinning operations. First, a series of eight pipe cylinders was sunk 3 ft. from the wall; then needle beams were placed in position to carry wall; next, the weight of the wall was imposed on a row of jacks; afterwards it was transferred to longer needle beams; and again portions of the wall were supported on jacks and girders; then new footings were built; the weight of the wall was transferred to these footings, when the needle beams were withdrawn, and finally the joint between old and new brickwork was closed, and the jacks were removed. This complicated series of operations made it necessary to lift the wall no less than six times, while every inch of its length was left clear for excavations, and all injury had to be carefully guarded against. No obstruction in the interior of the building was permitted, and it was stipulated that no inconvenience should be caused to tenants. The wall had to be constantly watched for many weeks, and the jacks had to be screwed up daily to compensate for continual settlement owing to the movement of the fine sand under the foundation. The successful completion of the task is particularly creditable to the skill and courage of the engineer, and of the contractors. Nevertheless, it appears that a great deal of trouble, anxiety and expense would have been saved by sinking the cylinder piers down to the rock formation immediately below the centre line of the wall, so that its weight would have been carried directly to the rock bed in the first instance. Only two operations would then have been required—the sinking of the cylinders, and the transference of weight to them.—*Eng. Record, Nov. 1, 1902*, pp. 417–19.

The Rio Grande Railway Bridge.

TWO excellent articles on the new cantilever-arch bridge over the Rio Grande River in Costa Rica, give a general view and details of the bridge, diagrams of the traveller for erecting the arch and shore spans, a strain sheet and material diagram. Theoretically, the superstructure consists of a pair of spandrel-braced arch trusses continued beyond the skewback piers to form cantilever arms, 47½ ft. long, which support the river ends of the two approach spans. For practical reasons, described in the first article, the top chord is a continuous riveted member, 684 ft. 11½ ins. long, between centres of abutment piers, and is designed to resist maximum tension and compression stresses. The structure is of special interest as being the latest and probably the largest span in Central America, and on account of the many difficult engineering problems connected with its dimensions and design. Neither its height (340 ft. above the water) nor length (685 ft.) is unprecedented when taken alone, but the combination of length of span and height is remarkable, and is only exceeded by the Garabit Viaduct and the Mungsten Bridge. The bridge is designed under Cooper's specification for a live load of 2,800 lbs. per linear foot of span, and a dead load of 3,000 lbs. per foot of span. The top lateral system is proportioned to resist a stationary wind load of 150 lbs. per foot of bridge; and the bottom lateral system for a stationary wind load of 150 lbs. per foot, and a moving wind load of 300 lbs. per foot of bridge. The braced arch was originally calculated in strict accordance with the method given in Prof. Greene's book on arches, but owing to alteration of dimensions the figures were re-calculated by a modified method developed by Mr. Cooper. The total weight of the superstructure is 932½ tons, and although built in the shops in one month, the work was so accurately done that no errors whatever were discovered in the field. During erection the shore arms were bolted up solid to form continuous trusses, so that the centre arch could be erected from each abutment with only vertical anchorages. After erection the bottom splice plates were removed, but the top panels were left solidly riveted up. The bridge was erected by fifty men in three months, and only about twelve of these men were experienced bridge erectors. Constructural engineers will be particularly interested by the strain sheet and material diagram, and the calculations given in article No. 2.—*Eng. Record, Vol. 46, No. 17*, pp. 390-4, *and No. 19* (pp. 434, 435).

The Strand Bridge.

SIR JOHN WOLFE BARRY has submitted a scheme to the Westminster City Council for the construction of a bridge across the Strand at the bottom of Wellington Street, so that north and south traffic may pass independently of the east and west traffic. In this solution of the problem, a street adjoining Wellington Street would be made, starting from Tavistock Street, and rising from that point in a gradient of 1 in 30 to a bridge across the Strand with a headway of 16 ft. 6 in. From the bridge the roadway would continue on the line of Lancaster Place with a gradient of 1 in 20, and join Waterloo Bridge at its northern end. The scheme would permit the erection of shops along a considerable part of Wellington Street below the new street, and along the raised road there would be a frontage of considerable commercial value. The Highways Com-

mittee of the London County Council have reported upon this question, and their present opinion is that no decision can be arrived at until after the formation of the new street from Holborn to the Strand.—*Journal Society of Arts, Nov. 14, 1902*, p. 930.

Automatic Regulators for Septic Tanks.

AMONG other devices for the regulation of septic tanks and contact beds, two which have recently been patented deserve consideration. The first of these "relates to improvements in apparatus for intermittingly charging or discharging liquid-tanks, and when employed for discharging tanks operates in such a manner as to permit the tank, whose discharge is controlled thereby, after being filled to remain filled for a certain determinate time before being emptied." It will be seen that this is particularly applicable to the conditions of a contact bed. The second invention "relates to an apparatus designed for intermittingly controlling the flow of liquid from a central tank or receptacle to a plurality of tanks or receptacles, and so arranged that said plurality of receptacles may be filled or charged in predetermined rotative order from said main tank or receptacle." This invention was designed more especially for use in connection with a septic tank so as to receive the effluent from the tank and to properly distribute it to contact or filter beds. *The Engineering Record, Nov. 8, 1902*, pp. 438-39.

Corrosion in Steel Buildings.

A RECENT report to the Massachusetts Institute of Technology contains some useful information as to the durability of steel in concrete. The difficulty of cleaning the surface as is done in experimental work is so costly as to be prohibitive in practical building construction, where the methods adopted are much less thorough. Protective coatings for steel are numerous, but as a rule such coatings are applied over rust, scale, and foreign substances on the surface, rather than on the steel itself. The trouble is increased by the fact that if the steel were perfectly cleaned it would not remain so long enough to be coated. Therefore, the practical constructor wants to know, not what happens to steel treated under laboratory conditions, but rather the results following ordinary manipulation. Prof. Norton hopes to undertake the latter line of investigation in the near future, and he invites the co-operation of architects and engineers. As examination has shown that steel plates $\frac{1}{2}$ in. thick, incorporated in the columns and beams of buildings, have lost more than $\frac{1}{8}$ in. in five years, there is clearly need for enquiry as to the life of such members. Some factors affecting corrosion are known, but others cannot be ascertained until after the lapse of several years. Ordinary building materials applied outside the steel, cannot keep moisture and CO_2 away from the metal, and as the latter is most plentiful in large cities, there is great risk of rust in such places. The practice of covering steel with Portland cement in some form affords the best protection yet adopted, but the composition of the mixture and the method of application are all important. Experimental results show that neat cement affords perfect protection, but that in more porous mixtures of cement with other materials, rust spots are found wherever voids or cracks exist. At present it seems clear that the metal must be thoroughly cleaned, and that a perfect film of neat Portland cement should be applied so as to completely cover the surface if corrosion is to be avoided.—**Prof. Charles L. Norton,** *The Engineering Record, Nov. 8, 1902*, pp. 442-43.

Workshop Construction.

A PREVIOUS article on this subject, considers the arrangement and general dimensions of the buildings required for the economical conduct of work, and its progress in various stages of completion through the several buildings. The present article relates to the constructional features of manufacturing buildings, which, in general, the writer recommends should have brick walls and an iron roof. He gives sectional drawings and descriptions of buildings suitable for machine-shops, foundries, forge-shops, power-houses, carpenter's shops, coal sheds, and storehouses. The question of foundations and floors is deferred, and will form the subject of another article.—**Oscar E. Perrigo,** *Machinery, Nov. 1902*, pp. 118-120.

The Rupnarayan Bridge, Bengal-Nagpur Railway.

THIS bridge was built by the Bengal-Nagpur Railway Company, and forms part of the direct east-coast line between Calcutta and Madras. The Rupnarayan is both a river and a tidal creek. The total discharge is about 563,530 cub. ft. per second, with a velocity of 10 ft. per second. The river is embanked on either side, and the flood-level is considerably higher than the surrounding country, the greatest depth of water before work commenced being 17 ft. below low water. The bridge consists of seven spans of 300 ft. (314 ft. 6 ins. from centre to centre of piers) and four spans of 100 ft., two at each end. The piers were all built for a double road,

but girders for one road only have been erected. The piers for the larger spans were founded on steel caissons, 88 ft. in height, 63 ft. in length, and 22 ft. in width, with semi-circular ends. Each caisson was divided by means of cross bulkheads into three dredging-chambers, 13 ft. 6 ins. in width, and weighed 385 tons. The river-bottom consists of a layer of hard blue clay, covered on the east side with silt, this clay extending to a depth of about 10 ft. Below the blue clay, yellow clay, varying in quality, was met with to a depth of 55 ft.; below this was sand, and in this sand the caissons were founded. Caissons Nos. 1 and 8 were sunk from ground-level; Nos. 5, 6, and 7, from islands; and Nos. 2, 3, and 4 were lowered and sunk from a floating staging erected on flats. The girders are of a semi-bowstring type, each span weighing 546 tons, They were erected on two pontoons of steel. 280 ft. by 40 ft. by 10 ft. These were built in Calcutta, and designed so that they might afterwards be used for the wagon-ferry over the Hugli in Calcutta. Each span was erected complete on the decks of the pontoons, and then floated over the piers at high water, the piers having previously been built only to a height of 18 ft. above low water. As the tide fell the pontoons floated away, and left the span supported on packings. The remaining 15 ft. in height of the piers were built as the spans were lifted. The lifting was effected with 150-ton hydraulic jacks. To obtain as much room as possible the spans were placed alternately on the sites of the up and down roads, and when at the full height those on the site of the down road were traversed over into line with the others. All the bricks and lime used on the works were burnt at the bridge site. The total weight on the base of each pier was 8,697·5 tons, or 6·7 tons per square foot. The actual construction was commenced in August, 1897, and the bridge was tested and passed by the Government Inspector on the 1st May, 1900. —**S. Martin-Leake,** *Proc. Inst. C.E. Session 1902-3. No. 4.*

POWER.

The Irregularity Factor of Engines.

In a paper read before the Verband Deutcsher Elektrotechniker, at Dresden, the author gives in detail the different methods he had tried for measuring the variation of angular velocity in engines. After describing a number of devices more suitable for laboratory work than for actual practice, he says that it does not seem possible to further improve the apparatus so that it will be suitable for other than instructional purposes, and it only remains to consider methods in which the irregularity factor is determined by measurement of velocity. After describing such methods and reproducing some curves of angular velocity thereby obtained, the author summarises his views as follows: (1) Every engine possessing an irregularity is also subject to a varying time of revolution, which often fluctuates more than the irregularity itself. (2) It is practically impossible to determine irregularity factors smaller than $\frac{1}{100}$. (3) It is unnecessary for electrical engineers to demand smaller irregularity factors than $\frac{1}{300}$, as experience has shown that we can get on with greater irregularities. The advantage resulting from this would be: cheaper machines, and governing more to the purpose.—**Dr. Rudolf Franke,** *The Engineer, U.S.A. Sept. 15, 1902,* pp. 628-30.

The De Laval Steam Turbine.

ORIGINALLY constructed for the direct driving of milk separators, the De Laval turbine was of the reaction type, very much on the same lines as the engine described by Hero, but the present construction of the machine is founded on the action principle. Steam is blown from stationary nozzles against vanes in the circumference of a wheel, and thereby the wheel is driven round. Velocity of the steam is obtained by adiabatic expansion in conical nozzles specially adapted for the purpose. Prof. Zenner has shown theoretically and experimentally that, if the steam is expanded adiabatically in the nozzles, all its potential energy is transformed into kinetic energy, and that the kinetic energy of steam thus expanded is identical to the amount of work which the same steam would have done if expanded in the same proportion in the cylinder of an engine. It is important that as much as possible of the kinetic energy of the steam-jet should be taken up by the turbine wheel and thus transformed into mechanical energy. The angle between the nozzle and the plane of rotation of the wheel is 20 degs., and in order to obtain the maximum efficiency the peripheral speed of the turbine wheel should be 47 per cent. of the velocity of the steam. The absolute velocity of the steam leaving the vanes is then 74 per cent. of the initial velocity, and the energy absorbed by the turbine wheel is then 88 per cent. of the kinetic energy of the steam. The peripheral speed of the De Laval turbine does not at present exceed 1380 ft. per second, which should make a steam consumption of 9·8 lbs. per theoretical horse-power. The part of the turbine which makes it possible to run the

wheel at this enormous speed is the "flexible" shaft, which runs on bearings at such a distance that a slight movement is permitted. There is a little vibration up to the "critical speed of the wheel," but when that is reached the phenomenon arises that vibration suddenly disappears and the shaft runs smoothly on its bearings. The phenomenon is termed the "setting of the wheel," and the reason for its existence has not yet been scientifically explained. Owing to its high speed the De Laval turbine cannot be applied to the direct driving of ordinary machinery, and speed is therefore reduced by means of gearing made on the double helical system, and machined with the greatest accuracy. This turbine is mainly used as a turbine motor for driving machinery by belts or ropes; as a turbine dynamo for direct driving of dynamos; as a turbine pump for direct driving of centrifugal pumps; and as a turbine fan for direct driving of centrifugal blowers and exhausters. The combination of the De Laval turbine to other classes of machinery is receiving consideration, but experiments are not sufficiently advanced to enable these machines to be put on the market. Several useful tables of experimental results are given in the paper from which the above notes are taken.—**Konrad Andersson,** *Trans. Inst. Engineers and Shipbuilders in Scotland, Nov. 1902,* pp. 9–34.

Cast *v.* Wrought Iron Steam Mains.

ONE of the chief aims of skilled designers of high-pressure steam piping is the elimination of as many joints as possible, and the first efforts should be directed to the steam main, the largest and most important high-pressure line in power plant. Very common practice is to make this main of wrought-iron pipe with cast-iron flanges, screwed, riveted or otherwise secured, using cast-iron tees at points where the branch pipes connect. This necessitates a great number of joints, and to remedy this draw-back some designers have used cast-iron, or cast-steel mains with flanges and nozzles cast on for the branch pipes. This reduces the number of flanged joints to one-half, to say nothing of the saving of all the joints between the wrought-iron pipe and the flanges. The objections against such pipes that are urged by many engineers are: (*a*) difficulty in obtaining sound castings, (*b*) first cost, (*c*) excessive weight, (*d*) inconveinence in providing "make-up" pieces to provide for inaccuracies in placing boilers and engines. Nevertheless, the writer believes that cast (not necessarily cast iron) mains will continue to grow in favour, and will at no distant time be in as common use as the made-up wrought-iron main. He then proceeds to discuss in detail the four objections urged and to give examples and illustrations exemplifying the design of systems of pipes, valves and connections for high-pressure steam.—**C. G. Robbins,** *Power, Oct. 1902,* pp. 24–28.

A Modern Flue and Return Tubular Boiler.

IN these days of water-tube boilers and Scotch boilers designed for high pressures, a boiler of the old-style flue and return tubular type, and a working pressure of 60 lbs., seems almost a step in a backward direction; yet a boiler of this type has been recently completed in the boiler shops at the Mare Island Navy Yard and installed on board the U.S. revenue cutter *Perry.* It would surprise many to learn how many boilers of this type are now in use on vessels in American waters, principally engaged in harbour and river traffic. As a rule these boilers are long-lived, the old boiler on this vessel having lasted 18 years. This longevity is probably due to the low pressures of steam used, accessibility for cleaning and repairs, and good circulation. One of the weak points about this design is the rapid deterioration usually met with in the bottoms of the water legs, owing to poor circulation and inaccessibility for cleaning. This can be in a measure prevented by filling the legs with cement to a depth of 10 or 12 ins. above the bottom, or up to a height of the level of the grate. The principal dimensions of the boiler in question are as follows:—

Length on base	15 ft. 9 ins.
Length over all, including steam chimney	17 ft. 0 ins.
Width of boiler front	12 ft. 9 ins.
Diameter of cylindrical shell ...	11 ft. 6 ins.
Height of boiler from bottom of legs to top of shell	11 ft. 6 ins.
Height of steam chimney above shell of boiler	7 ft. 0 ins.
Diameter of steam chimney ...	7 ft. 3 ins.
Grate area...	73·5 sq. ft.

The plates were worked as large as possible, thus avoiding to a considerable extent the numerous riveted joints necessary for this type of boiler as built in the earlier days. The thickness of the cylindrical shell is $\frac{5}{16}$ in.; of the front shell and side sheets, $\frac{13}{32}$ in.; of the furnaces and steam chimney shell, $\frac{3}{8}$ in. Double riveting is used in all parts of the shell, the rivets being $\frac{7}{8}$ in. and 1 in. in diameter. There are 130 4-in. tubes, No. 10 B. W. G. They are made of the best quality of seamless drawn steel, and

were each tested to a hydrostatic pressure of 500 lbs. per square inch.—*Marine Engineering, October, 1902.*

Steam-Pipe Covering.

In a paper read before the Association of Edison Illuminating Companies the following data are recorded. The figures were obtained as the result of an investigation conducted by the author on behalf of the Manhattan Railway Company. All the principal types of covering were tested on different parts of a 200-ft. length of 2-in. iron pipe, which was heated by electric current; and the pipe was isolated in order to avoid errors due to heat connection and radiation. Current sufficient to heat the pipe to approximately 370 degs. Fahr. (corresponding to a steam-gauge pressure of 160 lbs.) was kept on for three days continuously, in order to dry out the various coverings, after which they were allowed to cool off to the air temperatures before starting the test. The temperature of the room was kept between 27 degs. C. and 31 degs. C. during the entire test. Each section had about 600 readings taken, and where any doubt existed in reference to readings the entire series was gone over a second and third time with the gratifying result that it was conclusively shown that the test could be repeated with a variation of results not exceeding 2 per cent. The method of test was to put a current of sufficient quantity through the pipe to heat it to, say, 220 degs. Fahr., and keep this current on for a sufficient time to enable all sections to maintain a constant temperature (this period was found to be about ten hours), when readings of the millivoltmeter were taken on each section with simultaneous ammeter readings. As all the sections were in series electrically, the current was, of course, the same, so that no error could arise due to variation of current. A constant temperature having been obtained, it is evident that the watts lost in each section give an exact measure of the energy lost in maintaining a constant temperature, and from the watts lost the thermal units are readily calculated. The table below shows the result of the test values being reduced to loss in B.T.U. per square foot of pipe surface at various temperatures in the curves, and at a temperature corresponding to steam at 160 lbs. pressure per sq. in. After discussing the commercial aspect of the results obtained, the author adds that there seems to be no reason for the former practice of putting on different thickness of covering on different sized pipes, excepting the mechanical difficulty of applying a very heavy covering to a small pipe. This difficulty can be overcome by putting the covering on in two separate layers, and this plan should be used on all sizes, in order that the joints may be broken, as poor joints may reduce the efficiency of the best covering 6 per cent. or more.—**H. G. Scott,** *Elec. World and Eng, Nov. 29, 1902*, pp. 854–856.

	Covering.	Aver. Thick. Inch.	B.T.U. Loss per sq. ft. at 160 lbs. Pr.	% Heat Saved by Covering.
2	Solid Cork: Sectional ...	1·68	1·672	87·1
3	85% Magnesia: Sectional.	1·18	2·008	84·5
4	Solid Cork: Sectional ..	1·26	2·048	84·2
5	85% Magnesia: Sectional.	1·19	2·130	83·6
6	Laminated Asbesto Cork: Sectional...	1·43	2·123	83·7
7	85% Magnesia: Sectional.	1·12	2·190	83·2
8	Asbestos Air Cell [Indent]: Sectional [Imperial] ...	1·26	2·333	82·1
9	Asbestos Sponge Felted: Sectional...	1·24	2·556	80·3
10	Asbestos Air Cell [Long]: Sectional...	1·70	2·750	78·8
11	"Asbestocel" [Radial]: Sectional...	1·22	2·801	78·5
12	Asbestos Air Cell [Long]: Sectional...	1·29	2·812	78·4
13	"Standard" Magnesia: Sectional...	1·12	...	...
14	"Magnesian": Sectional	1·23	...	...
15	"Remanit" [Silk]: Wrapped	1·51	1·452	88·8
16	85% Magnesia: 2" Sectional and ½" Block ...	2·71	1·381	89·4
17	85% Magnesia: 2" Sectional and ½" Plaster ...	2·45	1·387	89·3
18	85% Magnesia: 2·1" Sectional and ½" Plaster ...	2·50	1·412	89·1
19	85% Magnesia: 2·1" Sectional	2·24	1·465	88 7
20	85% Magnesia: 2" Sectional	2·24	1·555	88·0
21	85% Magnesia: 2" Sectional	2·21	1·568	87·9
	Bare Pipe [From Outside Tests]	...	13·000	...

Starting Large Gas Engines.

A somewhat daring system is employed at the Snow Steam Pump Works, in starting the 1,000- and 4,000-h.p. gas engine gas-compressors in Cleveland. It cannot be better described than in the Works Manager's own words: "An auxiliary power-house is provided, containing small auxiliary gas engines, which, during the night, operate electric generators to supply light for the plant, and supply the storage-battery used for furnishing current for the electric igniters during the day and night. These auxiliary

gas engines are also connected to mixture compressors, which compress the proper proportion of natural gas and air (in the proportion of about 1 to 12) into a large tank. Connection is made from this tank to the ends of the cylinders, which are used for starting. The engineer turns this mixture under about 100 lbs. pressure into one end of one power cylinder, which causes the piston to move to the other end. The pressure is then allowed to escape from this end, leaving the cylinder full of mixture at about atmospheric pressure. He then goes to the other end of one of the other cylinders, and admitting mixture pressure to this end, forces the pistons back again to the other extreme position, compressing the mixture in the end of the first cylinder to which it was admitted. He then trips the igniter on this cylinder, which causes an explosion and starts the machine, and upon compression and ignition in the second cylinder to which the mixture is admitted, the reverse stroke is made under power, by which time the other cylinders have been rendered operative on account of drawing in their own gas and compressing same and exploding Very little trouble is experienced in starting the engines in this way. The mixture tank and its connections are designed to stand easily an explosion-pressure of about 600 lbs.; while, in addition to this precaution, a number of large relief valves are applied to the tank for the purpose of partially relieving internal pressure, should an explosion of this mixture take place in the tank. We question as to whether this method of starting would be permitted by insurance companies within the City limits; but, as we have before remarked, all our work in the gas engine line has been confined to the building of gas engine compressors, which are always located back in the country, and always some distance from cities or populous communities."—*Proceedings British Association, 1902.*

Steam-pipe Joints.

STEAM-PIPE joints must be well designed, and must be given intelligent attention. In the design of flanges for joints, great care must be exercised to see that the following conditions are fulfilled: (1) That the pipes are properly secured to the flanges; (2) that the flanges are of sufficient thickness; (3) that there are a sufficient number of bolts, and that they are properly spaced; (4) that the faces of the flanges are of sufficient width; (5) that the flanges are exactly parallel and do not have to be sprung together by the bolts. If any of these conditions are neglected, then trouble will be encountered in keeping the joint tight. While it is true that the best joint is the ground or scraped joint, its great expense and the fact that it must be kept permanent precludes its use except in comparatively few cases. With the advent of higher steam pressures the ordinary rubber gasket was found to be unsuitable for the increased temperatures. Gaskets made of asbestos in one form or another have met with much favour, especially for high steam pressures. For cylinder and valve-chest cover joints there is probably nothing made that can equal it for durability and efficiency, but where used for joints of pipes through which water is liable to be carried with the steam, it soon gives out. The hot water softens it, and it gradually washes away. Various combinations of rubber and soft metal have been invented, and some of them give very good satisfaction. Then, too, soft metal, such as copper, is used for gaskets, with more or less success, depending upon how carefully it is fitted. For permanent joints, such as those on boiler fittings, some engineers still cling to the old-fashioned cement style, made of red and white lead and iron filings mixed up to the consistency of putty. This mixture put between two pieces of wire gauze makes a very serviceable joint, if properly mixed and applied. No gasket should ever be put in place until it has been coated on both sides with a coating of blacklead or plumbago and oil or tallow. In making joints in steam pipes they should always be "followed up," as the saying goes, after the steam has been turned on. Leakage will generally occur if cold water is allowed to collect in the pipe. This is simply due to the expansion of the metal when the greater heat of the steam is applied. Draining a pipe thoroughly often saves the making of a new joint to replace one that is supposed to be worn out.—**C. A. M'Callister,** *Marine Engineering, Nov. 1902,* pp. 586-7.

ELECTRICAL ENGINEERING.

The Efficiency of Dynamos.

THE author deals with the determination of the efficiency of dynamo-electric machines. In such enquiries the direct measurement of the power supplied has always presented difficulties, and the substitution of electrical for mechanical measurement has usually been adopted. As an alternative to the electrical method, the author suggested, in 1893, that it might be possible to determine the mechanical power supplied to the generator from observations on the rate of change of the rotational energy of the armature under the conditions of full load. A similar test of efficiency was afterwards proposed by M. Routin in *l'Eclairage Electrique,* Oct. 24,

1896, and Prof. A. Hay described several methods for determining the moments of inertia of armatures in the *Electrical Review* of August, 1900. Mr. Ashworth then proceeds to show that his suggestion for the determination of I was to plot two retardation curves, one of the armature itself and the other of the armature loaded with a disc flywheel of known moment of inertia, the retarding forces being frictional forces only by preference. An example of this method for determining I is then given, and its application for obtaining the efficiency of a dynamo is demonstrated, the necessary data having been obtained from a Crompton series dynamo at Owens College, Manchester. —**J. R. Ashworth,** *The Elec. Rev., Vol. 51, Nov. 28, 1902,* pp. 887-9.

The Pacific Cable.

As may be seen from the sketch map here reproduced, the route for the new cable was selected in such a way that only British territory is touched. The lengths of the sections and dates when these were commenced and finished are given in the table below.

The portion between Vancouver and Fanning Island is the greatest length of cable ever laid in one section, and on this account the core was of greater area than that of the other sections, the weight of copper per naut. being 600 lbs., and of gutta-percha 340 lbs. in the same length. In the Fanning Island-Fiji section the corresponding weights are 220 lbs. and 180 lbs., while in sections C, D, and E the weights are 130 lbs. and 130 lbs. per naut. The armouring of the deep sea portion of the cable consists of 18 galvanised wires of No. 14 gauge, each wire taped and compounded. The breaking strain of this cable is about 8 tons, with between 3 and 4 per cent. elongation. Its weight in air is 2·1 tons per naut., and in water 1·15 tons per naut. Sections of the various cable constituting the Vancouver-Fanning Island section are shown. The rock cable is armoured with 10 wires of No. 2 gauge, then 6 wires of No. 00, the latter being wound spirally with a very short lay, the latter fact accounting for the peculiar shape of the section in spite of the wires being circular. This rock cable weighs 21 tons per naut. The heavy shore end weighs 16½ tons per naut., and is insulated first with 12 No. 6 gauge wires and then with 14 No. 1. The heavy intermediate cable is armoured with 10 wires of No. 2 gauge, and weighs 8 tons per naut., and the light intermediate weighs 5½ tons per naut., and is armoured with 12 wires of No. 6 gauge. In the cables used on the Fiji-Norfolk Island-Queensland and New Zealand sections, the core, as already stated, is 130/130, and the armouring is as follows :—

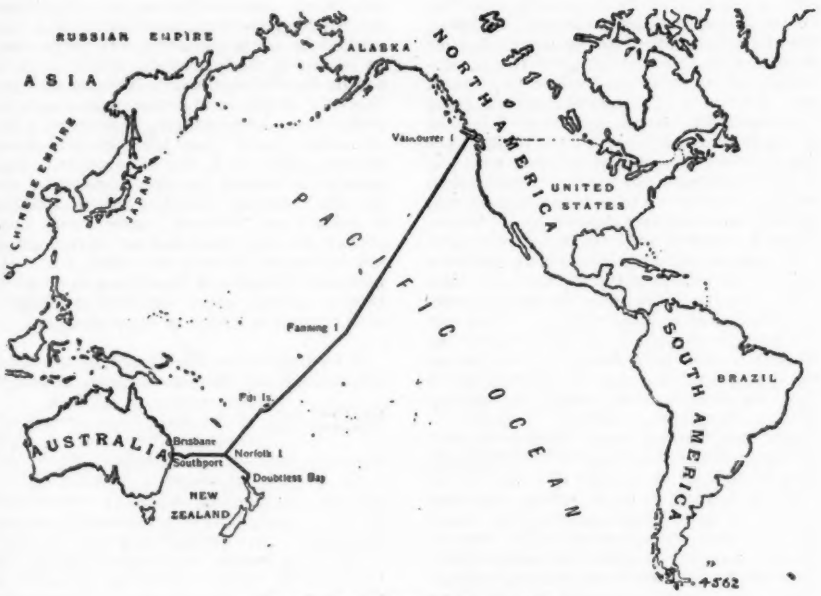
	Wires.	Gauge.
Rock cable	10 ...	No. 2
	6 ...	No. 00
Heavy Shore end	12 ...	No. 8
	14 ...	No. 1
Heavy intermediate	10 ...	No. 2
Light intermediate	12 ...	No. 8
Second light intermediate...	10 ...	No. 6
Deep Sea	16 ...	No. 13

The bay cable is twin, and is armoured with 18 wires of No. 9 gauge. For the shore ends and intermediate cables, brass tape is employed as a protection against the teredo. —*The Electrician, Nov. 7, 1902,* pp. 103-105.

Section.	Laying.		Length laid. Nautical miles.
	Begun.	Finished.	
	1902.	1902.	
A Vancouver-Fanning Island ...	Sept. 18	Oct. 17	3,458
B. Fanning Island-Fiji	Oct. 19	Oct. 31	2,043·1
C. Fiji-Norfolk Island	April 3	April 10	981·5
D. Norfolk Island-Southport ...	March 13	March 18	836·7
E. Norfolk Island-Doubtless Bay...	March 20	March 26	518·7
Total	...	...	7,838

Wireless Telephony.

AFTER describing some of the researches of other experimenters, the writer states that he has found a method of obviating the difficulties encountered in utilising such rapid oscillations as are produced by the disruptive discharges of an induction coil, and without employing condensers or coils for obtaining resonance in the circuits, but by simple transformation only. In his system of wireless telephony the discharge of low-frequency, high-potential currents is permitted to restore the electrical equilibrium or zero potential in the earth, that is to say, the discharge takes place in the earth, in contradistinction to a disruptive discharge which occurs in free air, and the former produces some phenomena which seem to be new. The primary of the sending induction coil is in series with the transmitter, battery, variator and key. The terminals of the transformer are connected to the earth and have a compensating capa-



MAP SHOWING ROUTE OF THE PACIFIC CABLE.

city. Bridged across the terminals of the secondary is a Leyden jar condenser. The receiver is formed of a closed circuit having the telephone receiver, a single dry cell and the secondary of a transformer in series. The primary of the transformer is earthed as in the case of the transmitting secondary of the induction coil. In 1901 apparatus was constructed and tried across the Delaware River at a distance of a mile, and in 1902 this was extended to three miles; the instruments were located on two hills, with a valley, stream, quarry, railroad, telephone and telegraph wires intervening. The reproduced voice was faint, but the articulation was not distorted. At the present time experiments are being made constantly at Rockland Lake, N. Y., and while it has not been attempted to increase the distance cited above, the instruments have been wonderfully improved with the result that the articulation is clear and loud enough for commercial purposes. Wirelessly operated signal bells have also been added. The value of wireless telephony lies in its application to speech transmission between vessels, supplanting the time-honoured and hoary steam-whistle. It may be used in isolated cases where bodies of water intervene and where cables would prove too expensive. It may be used where the right of way cannot be obtained for erecting poles or stringing wires; there are a thousand places where it will be welcomed. — **A. Frederick Collins,** *Elec. Rev., Nov. 29, 1902.*

LIGHTING.

A New Method of Applying Incandescent Lamps.

In a communication to the Société Française de Physique, the author describes an economical system of electric lighting by incandescent lamps. After pointing out that purely experimental tests hitherto published do not afford results coincident with those obtained in actual practice, the writer argues that rapid alterations of temperature due to the fluctuations of voltage invariably experienced represent an element which is seriously destructive to the carbon filaments. The filaments in lamps of 110 of 220 volts are particularly sensitive to the effect of fluctuations, and sensitiveness is inversely proportional to the thickness of the filaments. It is said that 110-volt lamps of 16 c.p., consuming 2·5 watts per candle,

lose 25 per cent. of their intensity after use for 100 hours, that similar lamps consuming 2 watts per candle lose 50 per cent. after 100 hours, that 220-volt lamps of 16 c.p., consuming 3·5 watts per candle, lose 17 per cent. after 100 hours. Further, that with a given equality of consumption, 110-volt lamps of 10 c.p. lose intensity much more rapidly than those of 16 c.p., and that 110-volt lamps of 5 c.p. deteriorate much more rapidly than those of 10 c.p. The economising system for alternating current devised by M. Weissmann is stated to yield much better results. Briefly described, the principle of the system is to lower the voltage of the current to 22 volts, and to employ lamps with thicker filaments suitable for the reduced voltage. Reduction of voltage is effected in the place where the current is used by a miniature transformer for each group of lamps, the dimensions of the transformer being about 10 cm. by 10 c.m. by 5 c.m. Several thousands of lamps have already been installed in Paris on this system by the Société l'Economiseur Électrique, and it is said that the saving effected is from 40 to 50 per cent. as compared with 110-volt lamps, and from 50 to 60 per cent. as compared with 220-volt lamps. One advantage of the system which deserves to be mentioned is, that lamps of 2 c.p., and even of 1 c.p., can be used where desired. — **G. Weissman,** *L'Electricien, Nov.*, pp. 314—16.

TRACTION.

British and American Railways.

In a recent lecture, Mr. Worsdell, locomotive superintendent of the North-Eastern Railway, said they were not cursed in America by a Board of Trade, and were able to do such things as fly-shunting express trains—letting them run loose into a station and bringing them up by means of the Westinghouse brake. Without such a free hand, he was convinced that they could not work their traffic in places like New York. One thing that astonished him was the steadiness of the running on American lines, one reason, he thought, being the elastic lines. If English lines were made in the same way, they would get more mileage out of their locomotives. American locomotives could go to a gauge of 10 ft. 6 ins., as compared with 8 ft. 6 ins. in England, and a height of 16 ft., compared with 13 ft., which gave the opportunity of building much more powerful engines. On one run, from Buffalo to Jersey City (447 miles), there were no signal cabins, the whole block system being automatically worked. The system was quite safe, and was spreading all over the States. Boston Station, with 775 trains in and the same number out each day, was worked by one signal cabin with seven men, by means of the pneumatic system now in use on the North-Eastern Railway at Tyne Dock. Some lines in Connecticut, originally steam worked, and running four trains a day at a loss, were now, after electrification, running 14 cars a day at a profit. That largely accounted for the decision of the directors of the North-Eastern Railway Company to "electrify" their local lines, though the Americans had the advantage in not having to protect the third rail. He believed the future of local lines in all parts of the country, where they had to compete with tramways, would be electrification.

Oil Fuel for Locomotives.

A PAMPHLET recently issued by the Baldwin Locomotive Works, discusses at length the subject of oil fuel. It is stated that oil has certain advantages over coal as fuel, amongst them being the following: (1) less waste of fuel, (2) economy in handling, (3) economy in handling ashes, (4) diminished repairs to locomotives, (5) economy in engine cleaning, (6) less waste of steam at the safety valve, (7) economy in cleaning ballast, (8) economy of space in carrying and storing fuel, (9) no fires from sparks, (10) no smoke and cinders, (11) possibility of utilising more of the heat. All these points are fully discussed in the pamphlet, which also deals with the calorific value of oil, the various forms of burners in use for atomising the oil as it enters the firebox, the most suitable forms of firebox, and other details in connection with this type of fuel.—*Railroad Gazette, Oct. 31, 1902*, pp. 834, 835.

Lancashire Tramways.

THE mileage of tramways in Lancashire amounts to about 750 miles, and in Liverpool alone, where 101 miles are in operation, 100 million passengers are carried yearly. The question of establishing through goods traffic has often been discussed. In a paper recently read before the Liverpool Chamber of Commerce, Mr. J. E. Waller said that the South Lancashire Tramways and the Liverpool and Prescot Light Railways are practically one undertaking, and arrangements had been concluded with the Corporation of St. Helens and the St. Helens District Tramways Company by which some 28 towns would be placed in direct communication with Liverpool, Manchester, Bolton, Farnworth, and other centres. There is an enormous goods traffic in South Lancashire which the railway companies cannot deal with, and the existence of a considerable

road traffic indicates clearly that if a cheaper and more expeditious service for goods on the tramways is organised, a very large traffic will be available. Various writers on the subject have suggested that special wagons should be constructed for the purpose of dealing with goods in the most effective and economical way. Sidings to works will have to be built to afford proper facilities. The possibilities of goods traffic to and from Liverpool are certainly enormous, but it is quite evident that it will have to be dealt with in an extremely prudent manner if the tramways are to fulfil their principal mission as a means of facilitating passenger traffic.—*Light Raily. and Tramy. Journ.*, *Nov. 7, 1902*, pp. 333—39.

TOOLS AND WORKSHOP PRACTICE.

Camming Automatic Screw-Machine.

THE article describes a simple method of setting out the cams of a full automatic screw-machine. This operation presents various difficulties to those unaccustomed to the management of such machines, and the method proposed should be found of considerable service.—**W. A. Teboult,** *Mech. World, Oct. 24, 1902*, pp. 198–200.

Machine-shop Formulæ.

THE author addresses himself to the development of methods for finding the cost and proportions of machines built in a series of sizes. The shop product may be systematised by the use of either formulæ, tables, or charts. Considering the two latter as the tabulated or graphic results of the first method the writer decides to deal only with formulæ. These he divides into two classes:—(1) Fundamental, used to produce the first of a type of machine; and (2) empirical, used to produce several sizes of this type of machine. Fundamental formulæ are those found in text-books and mechanical engineers' pocket-books, while empirical formulæ are to be deduced from data afforded by the types of machine construction produced by the aid of fundamental formulæ. The writer then takes an example, showing how an empirical formula may be obtained for proportioning the details in a series of engines with cylinders ranging from 10-inch to 30-inch diameter. When the design for a line of engines is thus systematised, the weights of any particular details may be determined prior to design or manufacture. Computations concerning the cost of materials logically follow the determination of volumes and weights, and are made with comparative ease, while the formula for the cost of labour is established partly by experience and partly by the methods suggested in the article. The computation of a final-cost formula is the last process described by the writer, and this formula is to be derived directly from those relative to the cost of materials and labour. By the use of such formulæ, estimates may be furnished with great ease for new work by substituting in the final equation the current prices of labour and material. When the estimates relate to sizes not previously made of a particular type of machine surprisingly accurate results may be obtained, and a standard design of known qualities can be submitted to the prospective customer.—**S. H. Moore,** *Machinery, Nov. 1902*, pp. 139-40.

MISCELLANEOUS.

Goldschmidt aluminothermic process.

THE "blast furnace and forge in a waistcoat pocket," as Dr. Goldschmidt's aluminothermic process was characterised by Herr Ostwald to the German Chemists' Association, formed the first subject dealt with by the author as the result of his official mission to the Düsseldorf Exhibition, where frequent demonstrations of aluminothermic welding were made by the Allgemeine Thermit Gesellschaft.

Thermit is the name given by its inventor to the intimate mixture of aluminium powder and the oxide to be reduced, which determines the reaction, without any previous heating of the mixture or of the refractory vessel containing it, by the ignition of a small quantity of a special powder containing baryum peroxide; and this ignition is rapidly propagated throughout the mass with considerable disengagement of heat, the reaction being quiet, and no gas or vapour being produced, as aluminium is not volatile. The high temperatures thus obtained, the reduced metal in a molten state free from carbon, and the scoria containing alumina resulting from combustion of the aluminium are utilised in various ways by Dr. Goldschmidt, whose first labours in this direction date from 1895.

Since Sainte-Claire-Deville produced aluminium in 1854, many *savants* have studied the reduction of metallic oxides by its agency; but the high price prevented any industrial utilisation of its remarkable properties. The cost per kilogramme diminished, however, from 125 fr. in 1885 to 2 fr. 75 c. in 1898 (say from 40*s.* to 1*s.* 1*d.* per lb.), while the quantity produced increased from 13 st. to 4,030 tons; and during the last few years investigations, with the object of rendering practical a utilisation of this metal's reducing properties, have been pursued simultaneously in France, Germany and America.

Theory of the process.—Deducting the quantities of heat lost by conduction and radiation, and admitting that a kilogramme (2·2 lbs.) of iron is produced by 0·484 kilogramme of aluminium according to the reaction $Al_2 + Fe_2O_3 = Fe_2 + Al_2O_3$, Dr. Goldschmidt showed that the combustion of aluminium furnishes 3455·76 calories per kilogramme (6220·368 B.T.U. per lb.), of which 1768 are absorbed by the reaction of the iron, 337 for its fusion and heating to 1600 degs. Centigrade, and 425·71 for the melting of the scoria. It follows that per kilogramme of iron produced there remain available 925·05 calories, and per kilogramme of mixture containing 50 per cent. of iron about 450 calories.

As to the combustion speed of this mixture, Dr. Goldschmidt affirms that it is from one to two seconds per kilogramme for a quantity near upon 10 kilogrammes (22 lbs.), rendering available 300 calories per second, which corresponds with the energy of 30,000 amps. at a tension of 40 volts. If it be further admitted, what, indeed, is confirmed by experience, that 100 kilogrammes (2 cwts.) of thermit can be burnt in 15 seconds, 3,000 calories are disengaged per second, corresponding with an arc of 300,000 amps. at 40 volts, which is not attained in such small space even with electric furnaces. In fine, thermit has a total energy equal to 188 times, and an available energy equal to 50 times that of the calcium carbide furnace.

Self-welding of iron and steel pipes.—Welding the lengths of a pipe for leading steam, compressed air, gas, hot water, etc., prevents leakage by suppressing joints; and the cost of welding is less than that of a good joint. The two ends to be welded, carefully cleaned, are brought together by a tightening appliance; and a plate-iron mould, surrounded by fine sand slightly damped, maintained by an outer case also of plate iron, is adapted to the place, the form and dimensions of the mould varying with the thickness and diameter of the tube to be welded.

A suitable portion of the mixture being placed in the crucible, a small portion of the igniting powder is added, and the lighting is effected by a special match. The operator, his eyes protected by smoked-glass spectacles, pours into the crucible the desired quantity of thermit, the combustion of which becomes complete in a few seconds, and he then lifts the crucible by means of a clamp and pours its contents into the mould. This operation requires a certain amount of skill; and care must be taken to prevent the jet of molten metal from coming into direct contact with the pipe, which, however, is protected by a tile. The scoria, which rapidly hardens on the cold metal surface, prevents contact of the thermit with the parts to be welded, and the incandescent mass, filling the mould, has in this case only to raise the parts to a high temperature, all then required being to bring pressure on the joint for determining the weld. There exists at Düsseldorf a pipe 100 m. (109 yds.) long, thus welded up in twenty places, that leads steam of 11 atmospheres (162 lb. per sq. in.) pressure.

Welding rails.—A continuous rail, especially advantageous for electrically-worked tramways, affords smoothness of running, uniform wear of rails and their preservation, together with that of the rolling stock. The electric conductibility of the track is better; and the copper wires generally employed for return of the current may be dispensed with. Experience has now shown the slight importance of theoretical objections connected with expansion, at any rate as regards tramways, so that the question is not whether rails should be welded, but the best means for effecting the weld without impairing the metal.

There are now three methods for rendering the rail continuous, viz., electric welding, the Falk joint, and the electrothermic process, which latter would appear to be the best from theoretical considerations. Thanks to the high temperature afforded it gives a true weld, while the circumstance that this weld is effected out of contact with the air saves deterioration of the rail, and this system has already received the sanction of practice, especially since Dr. Goldschmidt's invention of the self-pouring crucible.

In six tests of grooved rails round which thermit iron was run, the resistance to tensile strain, which varied originally from 68·9 to 84·7 kilogrammes per sq. mm. (mean 48½ tons per sq. in.) had only been reduced to from 66·2 to 80·8 kilogrammes per sq. mm. (mean 46½ tons per sq. in.), and the elongation from a mean of 12¼ to a mean of 10¾ per cent., while this diminution is largely set off by the strong continuous fish-plate constituted by the thermit iron under the flange. A bar of this iron exhibited at Düsseldorf, which showed a resistance to tensile strain of 39 kilogrammes per sq. mm. (24¾ tons per sq. in.) with 19 per cent. of elongation, gave on analysis the contents of C 0·1, Mn 0·08, S 0·03, P 0·04, Si 0·09, and Cu 0·1.

Repairs to steel, cast and wrought iron parts.—By running in a small quantity of thermit metal, the composition of which can be regulated at will, a defective casting or a broken part of steel, cast or wrought iron can be rendered utilisable; and many such parts and castings repaired by this aluminothermic

method were exhibited at Düsseldorf. It is thus that the Goldschmidt process is employed at many shops and foundries in Germany and Russia, chiefly for making good the defects in steel castings.

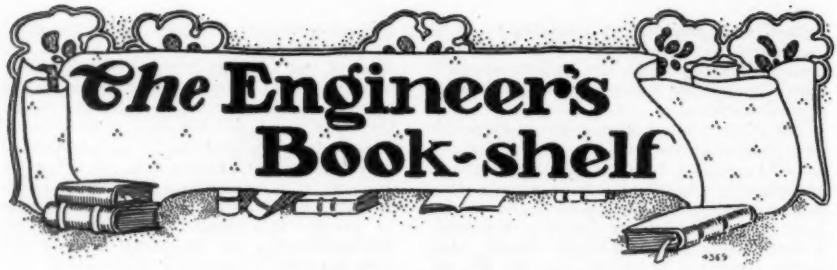
The high temperatures so easily obtained from aluminothermy are also utilised for the partial hardening or annealing of a part, and for removing shrunk-on cranks, wheels, propellers, etc., while M. Champy, the Company's representative at Antwerp, has used it for welding copper and for brazing iron on to copper. Moreover, by the aid of this process, various metals and alloys may be obtained absolutely free from carbon; and the scoria affords an artificial corundum to which Dr. Goldschmidt has given the name of "corubin." **M. V. Firket,** *Annales des Mines de Belgique, 1902, vol. VII., part 4,* pp. 969-992.

Smoke Abatement in Large Cities.

It is well known that smoke indicates imperfect combustion, while its prevention means a perfect burning of the fuel and consequent economy. The immediate cause of smoke from hand-fired furnaces is the fact that a large quantity of fresh coal thrown on the fire clogs up the air passages, and thus causes a scarcity of oxygen at the very time when it is most needed. When the fire is incandescent and burning brightly, if the draught is good, sufficient air will pass through the grate to complete the burning of both the gaseous and solid parts of the fuel. If this condition could be maintained permanently, there would be no trouble from smoke. This is the result which the mechanical stoker aims to accomplish. The feeding of coal uniformly along the grate, keeping the fire of proper thickness, and maintaining the conditions as to coal and air supply uniform, gives ideal conditions for economical burning of the fuel. Another device in common use is the down-draught furnace, having two grates where the fresh coal is fed to the upper, and the air draught is down through the fire upon that grate to the lower. All the volatile products mixed with the air from the draught are thus obliged to pass through an intensely hot fire on their way to the chimney, and are completely burned. The use of fire-brick arches and checker work maintained at a white heat will also help to complete the burning of the gases which pass under or through them. Where ordinary flat grates are used, fired by hand at irregular intervals, it is necessary to in some way vary the air supply to correspond. From what has been said, it is evident that this additional air, needed just after firing, cannot be supplied from below; it is accordingly introduced above the grate through the door, or through flues at the sides of the furnace, being either drawn in by the action of steam-jets or forced in by blower. The air or steam is turned on by the opening of the fire-door, and shut off after a suitable interval by a dash-pot or other automatic contrivance. It must be understood that the steam-jet probably takes no part in the combustion, but acts simply to create an induced draught, and to thoroughly mix the incoming air with the burning gases. Experience with air-regulating apparatus shows that air used in this way should not be pre-heated. If air is supplied in proper volume, the heat arising from the immediate combustion which takes place raises the temperature of the fire. In the matter of efficiency and economy, the blower is probably superior to the steam-jet. The author adds that as economy in fuel is a natural result of smoke prevention, the manufacturers of Cleveland are generally ready to adopt measures for the abatement of smoke. He then describes the manner of carrying out the work of smoke abatement in that city.—**C. H. Benjamin,** *Technology Quarterly, Sept. 1902,* pp. 265-71.

Silicated Cardboard Friction Pulleys.

The "diamond" cardboard, of remarkable hardness owing to silicate of ammonia, has lately been applied by its inventor, M. A. Denis, to friction pulleys for driving dynamos, centrifugal pumps, machine-tools, etc., a counter-shaft, driven by belt from the main shaft, being mounted on a carriage to slide in guides made by the action of a screw and hand-wheel, so that one pulley is brought gradually up to the other. The engagement is effected instantaneously but without shock, thanks to springs interposed between the screw and the carriage; and this arrangement permits of increasing or diminishing the speed, while suppressing belts or spur-gear for that purpose. With this arrangement the loose pulley is done away with and the disconnection is effected without shock by a mere turn of the hand-wheel. These pulleys can also be employed for reducing the speed of dynamos and steam turbines, while centrifugal pumps may be driven directly by a friction pulley making 70 revolutions, with great saving in first cost. The system is also applicable to the transmission of power at variable speeds in electric cranes, wood-working machines, etc.—**M. A. Lombard,** *Chronique Industrielle, 25th year, No. 42, 8 Nov., 1902,* pp. 481-2.



A Practical Treatise on Bridge Construction. By T. Claxton Fidler, M.Inst.C.E. (Third Edition, enlarged and revised. London: Charles Griffin & Co., Ltd.)

Probably the work now before us is the most complete treatise hitherto written on the construction of iron and steel bridges. Its starting point is found in the explanation of mechanical principles, and the presentation of experimental data, leading to the application of principles and facts as exemplified in bridge design and construction. Generally speaking, the language employed by the author is simple and the arrangement of the matter admirable; and, further, the graphic method is largely adopted for the solution of problems as an independent method of investigation. These features serve to recommend the volume to students, draughtsmen and engineers alike. It may, perhaps, occur to some casual readers that unnecessary space has been devoted to the elucidation of matters that belong to the science of mechanics and to the setting forth of others that are usually described in works on the strength of materials. Our opinion is that it would be inadvisable to omit a single chapter, for in bridge construction, theory and practice are quite inseparable, and as, to use the words of the author, "the best kind of theory is that which is most clearly understood," it is advantageous to have a lucid enunciation of theoretical principles from the standpoint of the bridge designer. Part I. of the treatise is devoted to "Elementary Statics," and it includes a detailed application of the geometric method to the investigation of bending stresses taking place in all bridges. This method of treatment leads naturally to a consideration of the "Comparative Anatomy of Bridges" in the first and second chapters of Part II. In classifying the various forms of bridge construction, Professor Fidler divides them into groups, genera and species, according to the distinctive mechanical features exemplified in their design. The family of girders is taken first, and is divided into groups conformable with distinguishing features that are suggested by diagrams of the kind of bending moments, as traced in the preceding chapter. "Generally," the author says, "every diagram of moments represents the outline of a framed structure which will carry the given load with a uniform horizontal stress in the principal members." This naturally leads to the establishment of two main types; the first comprising structures of uniform section, and the second those of non-uniform section. The types mentioned occur in all the divisions or classes into which bridges may be placed. The following summary will demonstrate the method of classification adopted by Professor Fidler. Division A: Structures affording continuous support to a uniform load. Group 1. *Parallel Girders:* the stress diagrams of which are of parabolic or arched form. Group 2. *Parabolic Girders:* the stress diagrams of which are of rectangular form. Group 3. *Arches:* derivable from, and allied to, girders of group 2. Division B: Groups 1, 2, 3 include inversions of structures comprised in the corresponding groups of Division A. Division C: Structures carrying a uniform load by detached intermediate bearers. Group 1. *Parallel Girders:* the stress diagrams of which are of polygonal form, each angle of the polygonal diagrams being inscribable within a parabolic curve. Group 2. *Polygonal Girders:* of which the stress diagrams are of rectangular form. Group 3. *Polygonal Arches:* derivable from girders of group 2. Division D: Groups 1, 2, 3 include inversions of structures comprised in the corresponding groups of Division C. Division E: This class includes "composite" and "combined" structures of various types. From the foregoing, it is easy to see that the method of classification adopted by the author is precisely in accordance with theory, and is sufficient in itself to give the

student an excellent insight into the science of bridge construction. Chapter 7 relates to "The Theoretical Weight of Bridges," a subject of practical importance, for the dead weight of the metal must be known before the calculated proportions of the structure can be finally accepted, and, in the case of very large bridges, the dead weight of the material must be ascertained before it can be determined whether the bridge can be built at all. Further, as the author points out, the calculation of weight affords an indication as to cost, and shows the comparative economy, in the true sense of the term, of different designs. A series of useful tables will be found in the same chapter, affording an approximate index to the weight of metal required in different forms of bridge construction, to carry the same uniform load across the same width of span. These tables and the formulæ relating thereto are clearly explained in the same chapter. Chapter 8, "On Deflection, or the Curve of a Bended Girder," is one of much interest and importance. The following extract contains a serious warning as to the exaggerated importance sometimes attached to deflection as a criterion for judging strength. Professor Fidler says:—"It is not an uncommon practice to 'test' a newly-erected bridge by observing its deflection under the passage of a heavy load; and it may be well to state at once that such a test affords no reliable indication of the *strength* of the bridge. If it should so happen that the structure is seriously or even dangerously deficient in strength, owing to any fault of design, workmanship, or material, it does not by any means follow that the bridge would exhibit any unusual deflection under the test load. Indeed, as the author points out, while the inspector is noting with satisfaction the moderate extent of the deflection, the bridge may at that moment be undergoing, at some critical part, a stress that is almost equal to the breaking strength of the material. The ascertainable change of form may be exceedingly small, while the accompanying increase of stress may be very great, and it should never be forgotten that even minute changes of form must be dangerous if they are accompanied by the substitution of "permanent set" for "elastic strain." After considering the laws governing the deflection of girders, and their application to the problems of bridge building, the author remarks that the initial "camber" required to bring any proposed girder into a straight line when it has been loaded, may be obtained by making each strut greater than its designed length in the proportion of $(1+f \div E)$ to 1; at the same time making every tie shorter than its designed length in the proportion of $(1-f \div E)$ to 1. Algebraic formulæ for the determination of bending moments in continuous girders involve somewhat intricate calculation, and an objection raised by Professor Fidler against such, is that their construction does not exhibit "the line of reasoning upon which they depend." All difficulty of the kind is removed by the aid of graphical diagrams, themselves illustrating the chain of reasoning on which the solution of any given problem hinges. As we have already said, these diagrams constitute an entirely independent method of investigation, and the geometric methods described in the present chapter are applicable to any conditions that may arise in connection with continuous girders.

We now approch the third section of the work, and very much regret that it is necessary to pass it with little more than incidental mention of one or two points. The section is really a treatise in itself, which many engineers would be glad to procure separately, if it were so published. The construction of the deflection curve described in Chapter 8 is employed as the foundation of a graphic theory of columns in Part III., where the theoretical and practical strength of columns and struts is discussed in an eminently rational manner. While careful examination shows that Professor Fidler has not overlooked any essential feature bearing upon the strength of "practical" columns, there are some points that ought to be more clearly emphasised. For example, the effect of intentionally non-axial loads is passed over too lightly; it is not explained that when external curvature is imperceptible, internal conditions, possibly due to unavoidable defects in the making of a built-up column, may. and frequently do, unintentionally give to a presumably axial load a certain amount of excentricity; and the student is not told plainly that the condition of fixity, as applied to the ends of a column, is one that is rarely attained in practice. An extremely valuable theory is worked out, with a co-relative formula, for the strength of practical columns, and the curves given by the formula under different conditions are plotted, with the results of various experiments, on a series of diagrams. These diagrams are of much value, but it would be an excellent feature if simplified forms of Professor Fidler's formula were given for office use. In our opinion, too much prominence is given to the stereotyped formulæ occurring in every engineering note-book, but which are utterly inapplicable and unreliable beyond the limits of the experiments upon which their empirical constants are based.

In the fourth and last section of the work, the principles, facts, and rules previously stated are applied to the practical design of bridges. Chapter 14 relates to "The Load on Bridges," and it should be noted that in the present edition the latest information is given, so that the student and the engineer may be fully equipped for dealing with the greatly increased loads due to the development of railway and road traffic. Chapter 15, on stresses due to movable loads, describes a simple geometrical method for the determination of stresses so caused, and shows how theoretical and experimental data as to working strength are to be applied to each class of bridge design. Chapters 16 and 17 are descriptive of different types of parallel girders, and of the methods by which their weight may be calculated. Referring to the apparent economy of American bridge practice, the author makes some comment, which ought to be marked by those innocent people who are always so ready to think British engineers do not understand their business properly. Professor Fidler says:—"The economy of American girders is partly due to the economical character of the details, by which a good deal of waste material is saved in the tension members, and partly to the adoption of such a liberal depth as will reduce the members to a very slender section. If similar proportions were chosen in English practice, it would generally be considered necessary, for the stiffening of the structure, to add such an amount of material as would annul all the advantage that is to be gained by adopting so great a depth." Further, he points out that, apart from the mere question of resistance to known loads, the stability of a bridge is always dealt with by the British engineer in such a manner that stability is infallibly ensured. In America fierce competition has fostered a tendency to accept theoretical calculations in practice without such additions as are necessary to supplement the known deficiencies of theory. The concluding chapters of the volume deal comprehensively with bowstring girders, bow-and-chain bridges, arched ribs, suspension bridges, cantilever bridges, and also with the important question of wind pressure. In looking back at the chapters which we have briefly reviewed, it is abundantly evident that each one has its definite use and value, and is as essential in the design of this masterly treatise as is every member forming part of a properly constructed bridge. The author has endeavoured to place at the disposal of his readers all the most recent information available at the present moment, and his work may be confidently recommended, not only to those engaged in bridge construction, but also to all who are interested in structural work involving the employment of iron and steel.

The Acts relating to the Supply of Gas and Water by Companies and Local Authorities. Compiled by Joseph Reeson, late Assistant-Secretary and Registrar to the Gas Light and Coke Company, 1902. (London: Butterworth & Co.) 818 pp., 8vo.

This book contains an exhaustive compilation of all the Public Acts and Enactments in force in all parts of the United Kingdom which relate to the supply of gas and water, both by companies and local authorities. It does not concern itself with legal decisions or judicial interpretations of clauses or sections, but is intended to provide a convenient book of reference for those who desire to know the law on the subject, or whose duty it is to carry out its provisions. The Acts are arranged chronologically, so that any particular one may readily be found, and so that the course of legislation may be easily followed. In 1874 the author published a smaller edition of his work, but in the intervening years there has been extensive legislation, widening the field considerably and introducing many new features, so that the present volume is to a very large extent quite new. Besides the Gas and Water Acts, the author has given all other enactments, or parts of them, which have a bearing upon the subject, as, for example, those providing for the prevention of damage to pipes by electrolytic action arising from the supply of electric energy for lighting or traction. The work is too extensive to allow us to attempt to give here a detailed description of its contents, and we must be satisfied with saying that the labour expended by the author in bringing together all these important enactments into one volume will be gratefully appreciated by all concerned with the subject. The greatest essential in a book which is to be used for reference is that an adequate index should be provided, and in this respect the present volume is wholly satisfactory. The index, in fact, occupies over 200 pages; in other words, a little more than one-fourth of the whole. The compilation is complete up to the adjournment of Parliament in August, 1902, and the author, in his preface, states that, should the present London Water Bill be passed, he intends to publish it as a supplement, uniform with the present work. We have no doubt that in its new form the book will meet with acceptance from that section of the public for whom it is intended.